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Implementing Green Roofs on Movie Theaters and Shopping Centers: Business Cases in Profitable Sustainability

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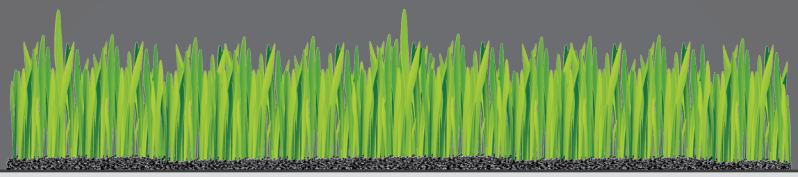

Implementing Green Roofs on Movie Theaters and Shopping Centers

Business Cases in Profitable Sustainability

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Introduction

PURSUING SUSTAINABILITY IS a profitable management strategy to take environmental and social benefits and turn them into business benefits. Many environmental measures reduce a business's costs or reduce the risk in its supply chain. Producing positive sustainability outcomes will also gain a business better public perception and reputation in the media. While some sustainability initiatives come at a high initial cost, the positive benefits from their implementation often lead to a positive net present value and realistic payback period for the investment. Installing a green roof on a commercial building is typically one of these realistically profitable sustainability initiatives.

A green roof is a vegetative layer on top of a traditional roofing membrane that produces significant environmental benefits. The insulation and evaporative cooling provided by the vegetation reduces the heating and cooling demand of a building, resulting in energy savings. In addition, the green roof retains and purifies stormwater leading to less and better quality stormwater runoff. This is sometimes incentivized on the municipal level through tax deductions and grant programs. For a business or building owner, these environmental benefits result in increased profitability. On top of the environmental benefits, the green roof reduces the need to replace the roofing membrane and increases the property value. Most importantly, the green roof provides the potential to re-brand a business or building as green and sustainable, growing the customer base and increasing customer loyalty, which leads to increased revenues.

Movie theaters and shopping centers are ideal commercial enterprises on which to incorporate a green roof. Both typically have large, flat roofs and a high ratio of impervious concrete and asphalt to productive retail area. Therefore, the owners can significantly cut stormwater taxes and reduce energy use through

the implementation of a green roof. In addition, both movie theaters and shopping centers are highly competitive industries and have customer bases that respond to sustainable and green branding of products. If one location can differentiate itself from competition through the installation of a green roof, it will have a comparative advantage and increase its revenue stream.

This paper will discuss the optimal green roof design for commercial property and the environmental benefits a business could achieve from that design. It will then introduce the basic economics of the movie theater and shopping center industries, demonstrating how these two industries are optimal businesses for green roof implementation. From that, the paper will propose two business plans, one for each the movie theater and shopping center. Within the business plans are target buildings for implementation and target customers as well as recommendations for financing the project and a projected return on investment calculation.

In the movie theater and shopping center green roof cases, a realistic payback period of 2-3 years can be achieved, resulting in additional profits for the following 40-50 year useful life of the green roof. Implementing a green roof is a positive environmental option that, more importantly, is a profitable business strategy.

Profitable Sustainability

From small businesses to major corporations, the role of a company's officers is to act in the best interest of the business. For a long time, this has been interpreted as maximizing the value of the company to investors. Corporate officers are legally bound to represent the best interests of the shareholders, liable for damages if they're not representing those interests. Companies have often viewed sustainability initiatives as costly endeavors that don't benefit a company economically. Therefore, corporate officers and small business leaders have often dismissed sustainability in business as contrary to their mission.

Corporate responsibility is a blanket term in business used to designate internal regulation of business activity affecting the environment and the social welfare of the greater community. Under the purview of corporate responsibility, many business sustainability initiatives are viewed as increasing production costs because they require "management time, capital investments and operating costs" (Lankoski 540). In addition, in many cases, there are intermediary steps taken in producing positive environmental and social outcomes such as "acquiring information or implementing training," which increase the cost to the business of that action (Lankoski 545). The true test for corporate officers is to determine whether a sustainability initiative will provide increased economic benefit to the firm or if those costs will decrease the performance of the business. With the possibility that environmental sustainability actions could come "at the expense of further profits," most corporate officers have decided to err on the conservative side with regard to their corporate role (Ubeda et al. 487). Federal and municipal authorities do post minimum standards of environmental and social compliance. However, the longstanding opinion of corporate officers is that environmental measures taken beyond government regulations are not in the best interest of the firm.

In the worst-case scenario, the pursuit of those initiatives could result in "divert[ing] management attention and capital from the real problems of the business," hurting the company, and possibly costing the officer his or her job. (Reinhardt 44)

In small businesses, as well, company managers shy away from environmental and social initiatives. Having a smaller scale, small and medium enterprise owners are often unaware of their environmental impact, are unable to accumulate the resources to tackle an issue, or are simply skeptical of the business benefits of corporate responsibility (Revall et al.). Representing 95% of private sector firms in typical industrialized economies, these small and medium enterprises make up 70% of global pollution, but only 13% undertake environmental measures. Even when they do take environmental action, the actions are often limited to "ad hoc 'end of pipe' measures" rather than strategic supply chain innovations (Revall et al. 277).

Another concern corporate officers have regarding environmental and social issues is that they will be accused of only taking on initiatives to boast the firm's reputation without any real change. This action, often colloquially called "green washing" has affected firms in a broad change of industries.

When the media has labeled a firm as a green washer, it can result in distrust from their consumer base or increased scrutiny from the government, both of which could be detrimental to business activity (Tang, Lai & Cheng 401). This is one additional reason corporate officers are often conservative in pursuing new environmental initiatives. The fear of being accused of "green washing" and concern over the economic losses that could result in devoting capital and time to initiatives has largely led to a sub-optimal level of sustainability action, which actually has the possibility of being very beneficial to a company.

The economic benefits for a business to engage in sustainability are numerous, ranging from increased efficiency, to beneficial regulation, to investment opportunities, to comparative advantage from consumers. However, there are still motivations to engage in sustainability outside of just profitability. In the business world, corporate officers are typically motivated by legislative compliance or through a feeling of ethical responsibility Especially in recent times firms "adopted ecologically responsive practices to merely meet legislative requirements," thereby engaging only in "those activities that are mandated." Meeting these legislative standards was a given for businesses wanting to avoid the fines and legal costs associated with regulator sanctioning. However, it led to them only focusing on their

own environmental practices and not taking a holistic view of supply chain sustainability, which is important economically as well as ethically. The ethical framework for sustainability typically stems from a "sense of responsibility and/or philanthropy rather than out of self-interest" (Paulraj 456). This is more typical of small firms, which may not have the manpower or information to accurately diagnose profitable sustainability options but rather engage in these initiatives out of a feeling of moral responsibility. However, the best sustainability outcomes, the ones that are the most proactive, resourceful, and creative come not from an ethical view but rather from the basis of "competitive or comprehensive motivations" (Paulraj 463).

There are indeed many legal or ethical motivations for pursuing sustainability in business; however the strongest motivation is one that all businesses respond to, increased profit. The environmental problems in our society today are constantly growing and have constantly growing costs. These costs have traditionally been borne not by the perpetrators of pollution and environmental damage, but by the society at large. As government policy responds to the increasing threat that climate change and other more local environmental problems pose, the costs have become more internalized (Goodwin). It's in this light that there's a possibility for firms to profit from "contributing to the solutions" and mitigating the damage of environmental issues (Reinhardt 43). This turns environmental initiatives from a cost to a "win-win" scenario where not only does society face less danger from environmental damages, but the firm, as well, ends up more profitable (Albino et al. 84). This isn't just an idyllic imagined scenario from a liberal leaning business leader; it's the situation in today's economy. A study

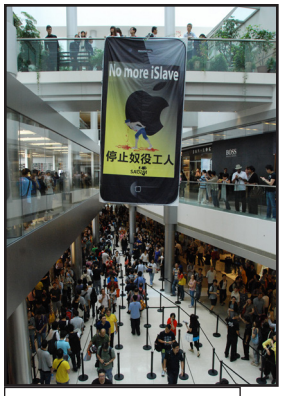
"Green Washing"

The idea of "green washing" stems from a very real consumer concern that corporate offiers are misrepresenting the sustainability benefits of products they're marketing. In 2009, for example, the Federal Trade Commission cited Kmart, Tender, and Dyna-E for deceptive claims on the biodegradable nature of their products. The citations resulted in settlements from Kmart and Tender while Dyna-E was taken to trial ("FTC cites K-Mart, Tender, Dyna-E for False Green Claims") However, there have also been instances of false accusations of corporate environmental and social damages. Multi-billion dollar software company Apple has long published a Corporate Social Responsibility (CSR) report, touting the steps the company has taken to mitigate its negative social and environmental impacts. In 2012, stage actor Mike Daisey appeared on NPR's This American Life with Ira Glass reporting on gross examples of dangerous working conditions at Apple factories in China. His statements caused wide-scale distrust

in 1996 analyzed data from 127 firms, finding that "efforts to prevent pollution and reduce emissions have a positive effect on a firm's return on assets, return on sales and return on equity within one to two years" (Wolf 94). There are four main reasons that environmental investments can become profitable for a firm: cutting costs through increased efficiency and decreased risk, providing competitive advantage over rival firms, enhancing cooperation with internal and external stakeholders, or assuring favorable treatment from government regulators.

The sizeable majority of low-cost environmental actions are actually just proper internal management on the part of corporate officers (Wagner 291). Oftentimes, firms are actually performing simple sustainable actions without knowing it. For instance, "avoiding an excessive waste of resources" is one of the most basic sustainability actions in which a firm can partake (Lankoski 542). It's often labeled as efficiency and not bundled with other traditional environmental performance measures. However, it exactly fits the earlier definition of a win-win scenario for a firm. Cutting excessive waste benefits the environment as well as resulting in increased profitability for the company cutting the waste. This is only one of many ways firms can use sustainability to cut costs; there's also "better resource utilization, increased [process] efficiency and improving adaptation to current environments" (Tang, Lai, & Cheng 403). All of these goals throughout the supply chain reduce the firm's capital costs while maintaining or improving the final product. In addition, environmental sustainability has taken ahold in corporate strategy as a "way of reducing the probability or cost of uncertain but adverse outcomes" (Reinhardt 45). For an example of this, firms have found that switching from

of Apple, with his testimony in direct contradiction to reports Apple had been publishing. Apple was soon labeled a green washer for having claimed it was a sustainable company while in reality it was not. It soon turned out that Mike Daisey's story was a combination of exaggeration and "significant fabrication," said Ira Glass in an apologetic blog post to retract the initial story (Glass). Apple survived the incident with no dip in stock prices and public opinion relatively unchanged. But they were "largely exempt from what other companies who have the same challenges would have to go through," due to how vastly popular the company is among the American people (Adams). For other companies in the country, accusation of "green washing" is a significant fear, as they might not be able to emerge unscathed from an incident as public as Apple's.



Chinese citizens protest Apple's supposed mistreatment of workers.

fossil fuel to renewable energy in production plants reduces the firm's risk of loss over uncertainty about energy prices. While this can be heralded as groundbreaking environmental action, it's a calculated decision on the part of corporate officers to avert risk.

Increasing efficiency or averting risk are often straightforward means of increasing profitability without significant cost to the firm while achieving competitive advantage can be more evasive. However, when a firm is able to successfully gain that advantage over rivals, it can be very lucrative. The key to deriving that competitive advantage is to "create value and then capture it from customers, suppliers or other economic agents" (Reinhardt 44).

One of the main ways companies capture the economic benefits of environmental action is through an improved reputation. Corporate officers themselves recognize "promotion of corporate reputation as a major competitive advantage." In fact, as many as 80% of officers list it as the number one value of "green initiatives" (Tang, Lai, & Cheng 401). This is because reputation is very important to customer's perceptions of a company's product or service. Especially in the lack of perfect information on that product or service, a customer's best inference to predict quality is the company's reputation (Tang, Lai, & Cheng 404). This is why establishing a company as the brand name for a given product is so sought after in market affairs. Kleenex, Clorox, Coca Cola, and others have achieved an advantage in their product markets through positive reputation and establishment as a household name. A company's environmental performance has been found to directly lead to their overall reputation, which can then factor into consumer decisions. While corporations "have made great strides toward improving environmental performance," there's still room for improvement in this regard as many have not "taken advantage of the full value

SEAT Solar Panels

Spanish automobile manufacturer SEAT, part of the Volkswagen group, installed 270,000 square meters of photovoltaic solar panels this past spring at their plant in Martorell, Spain. The panels will produce 15,000,000 kWh of electricity per year for the plant, covering "one quarter of the energy required" to produce one of their new models (Sunderland). In addition, the panels will provide a roofing cover for newly completed automobiles. Costing 35 million Euros, the project came with a high initial price tag for the company but will result in future cost reduction. The plant will be partially immune to increases in electricity prices with a significant percentage being generated onsite while reducing risk of adverse weather damaging the new auto fleet.

of leveraging their performance in communication and marketing initiatives" (First & Khetriwal 99). This is a key area for improvement for any company that has engaged in or is looking to engage in sustainability operations. While a company can seek to make environmental improvements and derive a beneficial reputation therein, the flip side must be true for economic benefit to ensue--consumers must respond to a firm's environmental performance.

Consumers in the past several decades have shown a willingness to make consumption decisions with environmental sustainability in mind, becoming "ever more aware of environmental issues and demanding that business communities take appropriate action in preserving the natural environment" (Paulraj 453). Capturing that benefit can come in one of three ways: increased customer loyalty, an ability to charge a premium on goods and services, or an increased market share (Lankoski). Adjusting for and anticipating these effects requires an understanding of the ways in which consumers make purchasing decisions. More importantly, it requires understanding how "environmental dispositions and attitudes actually play a role in [consumers'] consumption behavior" (First & Khetriwal 91).

Social norms are some of the most powerful driving forces behind consumption behavior, which is beneficial for firms looking to capture a sustainability benefit, as environmental concern has been on the rise for the past few decades. Consumers take norms from their families, their peers and coworkers, their friends, and more broadly, the perception portrayed in the media. Researchers have expanded work on consumption norms to include a range of other behaviors, such as dialect, movie choices, books read, sports played, etc. and have discovered a high correlation between these activities (Meek et al. 498). What this means for a business is that the perception of a product and the satisfaction derived by consumers is related to the various choices and activities the consumer takes in his or her life. As damaging the environment has become less and less accepted from a social perspective, "the ability for environmental entrepreneurs to come to market with new innovations" has risen dramatically (Meek et al. 497). The impact has led to the findings that 65.7% of US citizens "would recommend the top 20 socially responsible enterprises [as designated by the reputation institute] to others" while only 25.9% would recommend the bottom 20 (Tang, Lai, & Cheng 404). For companies, that difference is a huge margin in potential profit. If consumers are more likely

to recommend a product on the basis of social norms, the company can derive a large competitive advantage over rivals.

For a company to reach the point where its environmental performance is deserving of recognition by consumers and thus economically beneficial, it has to differentiate its product from competitors. This is often referred to as brand identity, "what a brand wants to be perceived as, what it 'transmits'" (First & Khetriwal 92). Touting sustainability, green supply chain operations, or a low footprint impact are all ways of enhancing the brand identity to differentiate a product. However, these attributes should be "stressed subsequent to the product traits desired by consumers" (Sandhu et al. 364). Consumers typically make a purchasing decision on performance, quality, and price and won't make a decision devoid of those concerns because of high environmental performance. Stressed in addition to those characteristics, environmental performance can provide additional incentive for a consumer. Environmental performance as a product characteristic will also be more effective when packaged together with the conventional characteristics. For example, pesticide free vegetables are not only environmentally friendly[1] but also thought to be better for the consumer's health (Reinhardt 59).

Marketing these benefits to the specific consumer with a tendency to make purchasing decisions based on environmental performance is key for a firm to capture the benefits of comparative advantage at the least cost. Luckily for firms, there's a basic profile for a green consumer that can generate the sustainability marketing plan. A green consumer's willingness to pay for environmental benefit is a mix of social expectations as well as "strictly economic criteria" (Reinhardt 60). Consumers of more affluent status often have the luxury to pay a premium for goods and services that meet positive social expectations, whereas consumers of less wealth will base product decisions more heavily on price. In addition, younger generations of consumers are more likely to support conscious environmental purchasing (Gerpott & Mahmudova). Not surprisingly, the best predictor of "pro-environmental purchasing behaviors," aside from wealth or income level, is consumer attitudes. The consumer who is "actively concerned with environmental issues and solutions to them," is also the consumer who

1 Pesticides used in agriculture often wind up in stormwater runoff and, if left untreated, in the water body that runoff leads to. Pesticides in water bodies result in eutrophication, an ecosystem effect where organic material leads to a boom in aquatic species. As the species population grows uncontrolled, the biological oxygen demand grows as well until the water body is reduced to little dissolved oxygen. At that point, the aquatic species populations collapse causing long-term harm to the water body's ecosystem. Eutrophication from pesticides in the Pacific Northwest has caused significant damage to the coastal estuaries that serve as a fishery for many Washington private fishing operations (Feldman et al.).

"constantly buys eco-friendly products" (Ukenna et al. 197). With this characterization in mind, firms can market products on the basis of environmental performance and then reap the benefits.

There are two main ways companies take the consumer preference for environmental goods and turn it into economic profits: mark-up pricing and comparative choice (Gerpott & Mahmudova 309). In mark-up pricing, the company will add a premium on top of the normal price, expecting that a significant number of conscious consumers will pay the premium rather than choose a competitor that may not perform as highly environmentally. Willingness to pay studies often agree with this notion, with consumers stating that they are "willing to pay more for environmentally friendly products" (Sanhu et al. 356) However, when it comes down to it there may be a psychological gap between saying that you'd like to purchase a sustainable good and actually doing it when faced with the decision. Researchers have found that despite 90% of consumers "indicating a preference for green products," many consumers "do not always vote with their money" (Sandhu et al. 357). When the decision is immediate, consumers often weigh price and quality considerations more highly than environmental performance, refusing to pay the price premium. Even when the environmental benefits are "explicitly labeled on the product," giving the consumer as much positive information as possible, the price may determine the purchasing decision (First & Khetriwal 100).

For this reason, adding a price premium for a good may not be the best economic decision for the firm; rather it's best to keep the price competitive with rival companies and rely on the environmental performance to sway consumers into purchasing a product. This is supported through research, as consumers will choose the product with better environmental performance when other characteristics such as price and quality are even (Pickett-Baker & Ozaki).

Aside from consumer engagement with the product, improved sustainability can benefit a firm economically through enhanced cooperation from internal and external stakeholders. As any firm tries to reconcile the demands of multiple stakeholders, oftentimes they will conflict in some way. Even in the realm of environmental performance, consumers may want cheaper goods while still valuing high environmental performance, employees may present apprehension to taking on new sustainability responsibilities, and managers have to make tough decisions about future changes in the market and law to prioritize environmental actions (Ubeda et al. 489). In this framework, firms need to "develop long-term strategic alliances with key stakeholder groups," to reconcile the varying demands and benefit from sustainability (Wolf 96). Cultivating those relationships over environmental

initiatives can "lead to the development of valuable intangible resources which may be sources of competitive advantage" (Lankoski 540).

One such advantage is favorable treatment in capital and insurance markets. Firms with a good reputation for environmental performance have opportunities in insurance markets not afforded to other firms, such as easier borrowing and reduced premiums. This is the case for a few reasons. As discussed previously, firms will often have decreased risk if they've innovated along the supply chain in terms of environmental performance. Since risk is one of the main determinants of borrowing rates, reducing risk will lead to better terms from lenders. There are also specific ethically driven investors that will only invest in companies touting sustainability along with profits. This adds an additional possible investor for the company, which in and of itself is economically beneficial, but also ethical investors tend to offer better terms of agreement than other lenders since they have motivations beyond just return on investment. In addition, sustainable companies will be viewed more favorably by the general public, which can lead to a higher stock price if the company is traded publicly (Lankoski).

The most important stakeholders, though, for a firm to engage are the employees themselves. For starters, the actual sustainability initiatives will likely be carried out and coordinated by the firm's employees. If internal "organizational structures have been designed that facilitate sharing knowledge and experience," the initiatives will have better outcomes (Wolf 97). Often, sustainability will fall outside the purview of traditional employee responsibilities, so sharing this knowledge acts as a sort of "on-the-job" training. The success also hinges on the employees having a "clear responsibility for sustainability matters" (Wolf, 97). This will lead to more passionate and devoted work from the staff on sustainability, which can then generate better outcomes. The better that a firm performs in its sustainability goals, the greater the economic benefits will be from efficiency, risk reduction, and comparative advantage. In addition, integrating employees into the sustainability process has been correlated with higher retention rates, improved worker health, and a boost to employee morale, which can all lead to greater productivity in the firm's normal operations (Lankoski).

Sustainability often comes at some initial cost be it reducing emissions, switching to renewable suppliers, or producing environmental impact statements. However, corporate officers should not only undertake the necessary cost of sustainability initiatives to comply with legislation or fulfill a sense

of ethical responsibility. Sustainability can directly and indirectly lead to increased profitability for a company through increased efficiency, consumer loyalty, and comparative advantage over rivals.

Portland Central Library Green Roof

Green Roof Design

For several centuries, planted rooftops have been an architectural feature of houses and commercial buildings for a number of environmental and aesthetic reasons. Modern green roofs, also called living roofs, involve a vegetated layer atop a growing medium. Beneath that are drainage and waterproof membrane layers to drain water to the gutter system and protect the surface of the roof. Generally, green roofs are separated into two different categories: extensive roofs and intensive roofs.

Extensive green roofs typically feature a growing substrate of less than 6 inches and only contain shallow rooted, drought resistant grasses. Extensive roofs typically cost between $5 and $15 per square foot to implement above and beyond the cost of a traditional roof. Intensive roofs are classified as having a deeper substrate and featuring plants with longer root systems, often requiring irrigation or watering and infusion of organic material. Implementing an intensive roof is more costly than an extensive roof because of the increased substrate depth and necessary materials. It will generally be between $20 and $60 per square foot, not including any structural adjustment to the building that would need to be done (Bianchini & Hewage, "Probabilistic social cost-benefit analysis for green roofs: a lifecycle approach"). Extensive roofs have been common in parts of Europe and Asia for many centuries but have only recently become more popular in North America (Snodgrass & Snodgrass 18). Previously, green roofs in North America were of the intensive kind in densely populated urban areas and featured many different plant types and growing seasons, resulting in the common name of a rooftop garden. More recently, researchers and designers have begun experimenting

with semi-intensive roofs, which feature areas of both extensive and intensive substrate depth designed together on one roof.

Table 1: Comparative Green Roof Design

	Extensive	Intensive	Semi-intensive
Substrate Depth	Up to 6 inches	Over 6 inches	Mixture of sections under 6 inches depth and sections over 6 inches
Weight	20-30 lbs per sq. ft.	Around 70 lbs per sq. ft.	Sections of both, average near 45 lbs per sq. ft.
Structural Capacity Necesssary	Minimal strucutral adjustment, if any	Significant design modification or structural adjustment	Some structural adjustment, but more flexible than intensive system
Plant Type	Drought resistant grasses and flowering plants such as Sedum	Deep rooted plants and shrubs, trees, perennial growth	Sections of deep rooted plants surrounded by drought resistant grasses
Watering	No irrigation necessary	Surface or subsurface irrigation to supplant natural rainfall	Broad irrigation for deep rooted sections
Organic Matter	0-10%	Greater than 10%	Around 10%, as necessary
Maintenance	Low	High	Medium
Cost	$5-$15 per sq. ft.	Over $30 per sq. ft.	$20-$25 per sq. ft.

Semi-intensive roofs can range in substrate depth from 12-100cm and are composed of 6-12% organic content by mass, supporting "shrubs, coppices, grasses and other groundcovers" (Kotsiris, Nektarios, & Paraskevopoulou 311). Certain areas of a semi-intensive roof will be specially designed for perennial plants having "zoned irrigation or deeper substrates" (Durhman & Rowe, "Effect of Watering Regimen" 1626). Semi-intensive systems have often been viewed as a sustainable adaptive approach to green roofing, combining "drought tolerant plants with high water retention capacity," while simultaneously requiring less load-bearing capacity than traditional intensive green roofs (Kotsiris, Nektarios, & Paraskevopoulou 316). Semi-intensive roofs typically cost between $20 and $25 per square foot depending on the exact makeup of the roof.

In choosing vegetation for a green roof, one of the main concerns is the survival potential of the species. Common logic suggests that native species would be best adapted to the local climate and could therefore survive without additional maintenance, such as watering. However, "native prairie taxa" often "rely on deep extensive root systems to obtain moisture, a situation that rarely exists on a green roof" (Durhman & Rowe, "Effect of Watering Regimen" 1623). Green roof designers have thus turned to *Sedum*, a large category of flowering plants, for planting on extensive green roofs to survive within the climactic extremes and "outperform other potential green roof taxa" (Durhman & Rowe, "Effect of Watering Regimen" 1623).

Sedum is a facultative CAM plant, meaning its photosynthetic pathway shifts from C3 to CAM under stressed conditions. The C3 pathway is the most common carbon fixation mechanism for plants as opposed to the more complex C4 pathway. C3 photosynthesis relies on a heavy uptake of ground water because the majority of water used in the inner processes is released through transpiration. The CAM pathway, short for crassulacean acid metabolism, is an adapted feature used by plants predominantly in dry and arid conditions. During daytime, CAM plants close the stomata to prevent transpiration, opening at night to collect carbon dioxide, which can be used in photosynthesis the next day. By switching between the two pathways, *Sedum* is able to grow and thrive in low water environments while maintaining some of the benefits of transpiring plants, such as evaporative cooling (Bousselot et al. 518).

While there are different types of *Sedum*, many studies have found most varieties to fulfill the basic requirements of green roof taxa. During establishment of the vegetated layer, the goal is "to achieve 100% coverage as soon as possible" (VanWoert et al., "Watering Regime" 663). This helps

to prevent weeds from taking hold, reduce erosion, and achieve the aesthetic desired. One benefit of using *Sedum* for the vegetated layer is that in the presence of irrigation or watering, it will switch to the C3 pathway and provide full coverage sooner than other plant types only using a CAM fixation mechanism. After coverage has been reached, irrigation can be eliminated, and the *Sedum* will then thrive in the shallow green roof system (VanWoert et al., "Watering Regime" 663). While other species have been tested in the scope of green roof vegetation few can broadly "match the growth and survival performance" of *Sedum* species. (Bousselot et al. 518). One criticism of *Sedum* use is that it may not live up to the aesthetic vision that owners and tenants imagine of a green roof. *Sedum* is undoubtedly different in appearance from the non-native grasses that frequent lawns in the US. It's therefore important that green roof designers clearly communicate how a green roof will appear aesthetically so that there is no disappointment on part of the owners and tenants.

Sedum species look different than the grass lawns owners sometimes expect on roofs.

However, in specific situations, plant species aside from *Sedum* can be better suited in terms of environmental benefit and survival rate (Durhman & Rowe, "Effect of Watering Regimen" 1627). Species that are "long-lived, that reseed themselves, or spread vegatively" provide coverage for the vegetative layer and will continue to survive without undue maintenance (Getter & Rowe, "Substrate Depth Influences Sedum Community on a Green Roof" 401). One such example, flowering plant genus *Stachys*, was found to provide similar environmental benefits in extensive green roof systems, as "water deficiency did not significantly increase leaf temperature" (Blanusa et al. 102). In fact, one study found that *Stachys* outperformed *Sedum* in terms of temperature reduction in both "well-watered and dry regimes" (Blanusa et al. 102). However, while *Stachys* is a drought-adapted species, capable of surviving in shallow substrate systems, it may not be as resilient as *Sedum* in

surviving extended periods of extreme heat. This limiting factor demonstrates the need to evaluate a green roof's vegetated layer on an individual basis with regards to climactic conditions and substrate characteristics.

In an intensive or semi-intensive roof system, there are many more species of plants available for the vegetated layer than in an extensive system. With the availability of deeper root systems, traditional vegetables and herbs are common fixtures in intensive gardens. However, as previously discussed, one important characteristic of an environmentally successful green roof is the existence of immediate and continued coverage. Seasonal plants can end up leaving the substrate exposed for certain times of the year, which can undermine the environmental benefits of reduced energy use and stormwater retention. Seasonal plants do provide a potential draw to the customers of the building implementing the green roof. The ability to grow produce and herbs is very rare in a traditional urban setting, which makes the building unique, a source of comparative advantage in business. Visually, the presence of developed deep-root vegetation over *Sedum* gives credence to the classification as a garden, a positive reputational distinction. The harvesting of that vegetation is also an important marketing feature. While it adds to the operation and maintenance costs of the roof, it allows the building to hold a farmer's market or, at the least, sell the produce and herbs on the ground floor. It also can encourage involvement from the community. Many urban garden plots are managed by volunteers from the surrounding area. If the green roof intensive area is sectioned into garden plots, it's an opportunity to bring community members to the building in the form of volunteer gardeners.

Below the growing media lies a drainage layer that traditionally is composed of well-graded soil, which retains moisture and filters out organic pollutants harmful for waterways in the runoff of stormwater. One popular alternative to soil is porous stone material. However, the demand and extraction of "stone materials lead to a large environmental impact," including landscape destruction, deficit in waste management and other impacts during the processing phase of the materials (Vila et al. 102). Recent experiments have tested inorganic materials such as rubber tire crumbs as an alternative, sustainable drainage layer for green roof design. By using a lightweight substrate material, the same depth can be achieved with less weight bearing capacity necessary. Rubber tires are "30-50% lighter" than traditional well graded soil while providing eight times better insulation and "ten times better" drainage (Vila et al. 103). Rubber crumbs also provide less of a lifecycle environmental damage as they're recycled from landfill bound car tires. Outside of the rubber tire crumbs, other studies have tested expanded clay and shale for use in the substrate drainage layer providing beneficial moisture

and nutrient holding capacity (Zheng & Clark 1208). Rubber crumbs, and other lightweight synthetic materials, provide an opportunity for increased prevalence of green roof implementation across the US. The lighter material reduces the cost of installation, which can turn projects that may not have been profitable in years past into beneficial business initiatives.

In implementing a green roof, there are a variety of issues that must be considered in the process of developing the final design. First and foremost is the building's ability to bear the weight of the green roof. Weight bearing capacity is one of the main reasons "roof gardens cannot yet be considered a common practice" (Panayiotis et al. 618). The weight of the growing substrate causes a significant burden to the frame of the building on which the roof is situated. The concern is heightened significantly with regard to older buildings, which may have deteriorating support or were constructed in a time of more lax regulations. In evaluating potential buildings for installing a green roof, low weight bearing capacity will be an additional cost or sometimes entirely prevent the possibility. In cases where structural amendments are necessary and cost isn't prohibitive, at a minimum the construction will take longer and be more complicated. For these cases, designing a green roof with a lower necessary weight capacity can improve the return on investment.

After weight bearing capacity, the heat effects of the surrounding climate, including drought, play a major role in determining the composition of the green roof. The microclimate of the roof substrate and layers can vary greatly from freezing temperatures to blistering heat in periods devoid of precipitation. Any plant selected for the vegetative layer "must survive [those] extremes" while maintaining the environmental benefits of a green roof (Getter & Rowe, "Substrate Depth Influences Sedum Growth Community on a Green Roof" 401). An owner or designer will also adjust substrate depth to optimize growth and environmental benefit. In general, the deeper the substrate, the better the plants will grow and the more durable they will become. In one study evaluating growth under typical conditions, plants grown "in the deeper substrate depths of 5.0 cm and 7.5 cm exhibited higher survival rates than those grown at the 2.5-cm depth"(Durhman & Rowe, "Effect of Substrate Depth" 590). This is mainly because deeper substrates mitigate the damage to the vegetated layer of extreme weather events as the roots will be further away from the surface and, therefore, better insulated (Durhman & Rowe, "Effect of Substrate Depth" 591). The better insulated the roots are, the less temperature fluctuation they'll be subject to. Fluctuation can cause rapid shifts "in and out of dormancy," decreasing the plants' ability to grow and survive. One study in Quebec found sig-

nificantly more freeze damage in substrate depths of 5cm compared to 9cm and 11.5cm equivalents but no measurable difference between the 9cm-11.5cm depths.

In addition to optimizing the depth of the substrate, there's significant research done on providing the best possible growing media within the constraints of the green roof. Using a lightweight substrate material can allow deeper substrate depth without changing the physical structure of the building. The substrate layer has to be lightweight and physically stable above all else to protect the roofing membrane and structural integrity of the building. This is one reason that large amounts of organic matter and compost are generally not present in green roof systems. As organic matter interacts with plants, it decomposes and shrinks in size, which can cause major shifts in the structure of the substrate layer (Sailor & Hagos 2299). Beyond that requirement, the growing media must be chemically inert and able to retain "adequate amounts of water and minerals for sufficient plant growth" (Kotsiris, Nektarios & Paraskevopoulou 311).

With the expansion of extensive roofing systems in the US, designers have begun debating the merits of using irrigation and fertilization. In intensive and semi-intensive systems, irrigation or watering is necessary to ensure survival and growth of plants. Including irrigation in the implementation of a green roof is costly and requires further ongoing maintenance, reducing the return on investment for an owner. However, in the cases where watering is necessary for the survival of the vegetated layer, installing irrigation can be less costly than paying staff to water the roof by hand on a consistent basis. There may be little necessity for watering an extensive roof vegetated with *Sedum* or similar species as naturally occurring precipitation will be sufficient for the grasses to remain viable as a vegetated covering. However, in extensive roofs with a shallow substrate depth, not as much stormwater will be retained, causing the *Sedum* to dry out and lose effectiveness. Vanwoert found that watering was necessary once every two weeks in a substrate depth of 2-cm for *Sedum* to survive while that lessens to once every four weeks when the substrate depth is increased to 6-cm (Durhman Rowe, "Effect of Substrate Depth" 592). Beyond that depth, *Sedum* will typically survive without maintenance using only natural precipitation. Even in those cases, though, it may make sense to manually water the vegetated layer as it initially takes hold on the roof to decrease time to full coverage and increase the initial survival rate.

In a similar vein, there's also debate about fertilizing the initial planting of *Sedum* or other species to promote better, quicker coverage. One study found that the basic fertilizers of nitrogen,

phosphorous, and potassium can "be applied after a fall installation to establish vegetative coverage, develop plant biomass in the next season, and enhance the leaf greenness of *Sedum* species" (Clark & Zheng 1779). By increasing the initial coverage and building up biomass, fertilizers help improve the effectiveness of the green roof immediately. Greening the leaves of the plants doesn't provide any direct economic benefit to the owner but can increase occupant satisfaction (Lewis Preface). In addition, fertilizers can reduce the "risk of frost damage in plants," promoting survival even in tough microclimates (Clark & Zheng 1775). However, there are also a number of downsides associated with fertilizer use. For one, fertilizers are one of the main perpetrators of environmentally damaging runoff as the organic materials promote eutrophication and subsequent biodiversity loss.[1] Requiring fertilizer also makes the initial planting more costly. Not only does the fertilizer itself have a monetary cost, the fertilization makes the planting more labor intensive, costing the owner further. Because of these concerns, fertilizer has only widely been used in green roofing on intensive and semi-intensive roofs where the diversity and growing regimen of plants demands it.

For the business looking to implement a green roof to increase profitability, the best option is a semi-intensive roof with a mixture of drought-resistant flowering species and deeper-rooted produce and herbs. This design reduces the weight bearing capacity necessary for an intensive roof while still producing the tangible benefits of deep substrate depth. Most importantly, the business can allow community volunteering to upkeep the intensive area and have produce and herbs to harvest and sell. To mitigate the weight of the substrate depth, a recycled material such as rubber tire crumbs should be used for the drainage layer. Some irrigation will be necessary to maintain the vegetation in the intensive patches and can also help the extensive areas achieve full coverage faster. While organic nutrients could help the growth of deep-rooted vegetation, it would negate some of the environmental benefit of the roof and cause structural problems and should therefore be avoided. This green roof design holistically provides a beneficial option to a business through environmental benefit and marketability.

1 One of the main environmental benefits of a green roof is the retention and purification of stormwater that would otherwise find its way to storm sewers and waterways. This topic will be covered in the next section– Green Benefits on Page 31. While the green roof typically naturally purifies stormwater, fertilizing the green roof will add organic pollutants to the resulting runoff, detracting from the overall environmental benefits.

Aerial view of the Chicago Mayoral Hall green roof

Green Roof Benefits

American citizens living in urban areas suffer from higher rates of exposure to environmental risks than rural citizens (Jackson). High concentrations of people, large industrial facilities, relatively little natural landscaping, and frequent automobile transportation all contribute to current problems. Planted, vegetated roofs provide one means to address many of these issues. While an owner or tenant assumes some of the environmental benefits of a green roof, society at large retains the majority. As such, there exists a limitation in the free market for the demand of green roofs. However, states and municipalities often levy taxes on commercial buildings for the environmental damages they cause and subsidize design features that mitigate these damages. Therefore, addressing environmental concerns through measures such as a green roof can bring direct business benefits to the owners or tenants of the property.

Often times, rooftops in cities can reach up to 180 degrees Fahrenheit. Concrete, asphalt, and tile are the main materials used in rooftop construction and have a very low albedo, meaning they retain a high percentage of the infrared heat radiated by the sun. As a consequence, buildings require air conditioning to maintain occupant comfort and safety. Even when the temperature outdoors is comfortable, indoor temperatures tend to be on the order of 10 degrees Fahrenheit hotter without any climate control. Green roofs insulate a building from heat gain, reducing the need for air conditioning and saving money for the building owners or tenants on energy costs.

The green roof substrate layer and plants provide the majority of the cooling benefit for the rooftop. Compared to just the membrane and drainage layers, the substrate and plant material significantly retains less infrared heat (Getter et al.).

Table 2: Green Roof Benefits

	Environmental Benefit	Green Roof Mechanism	Economic Benefit (per sq. ft.)
Avoided Costs			
	Stormwater Runoff	The capacity of the green roof to absorb stormwater runoff reduces the need for other stormwater infrastructure installed on the building (only for new construction)	**$2.80-$30**
		Municipalities often charge a stormwater tax to property owners to cover the costs of treating stormwater runoff–implementing a green roof reduces this monthly tax	**$0-$0.034 (Annual)**
	Reduced Energy Use	By insulating a building, a green roof reduces the need for heating and cooling, thereby reducing energy use	**$0.037-$0.084 (Annual)**
New Revenue			
	Design/Construction Grant	There are often federal, state, and municipal grant incentives for installing a green roof or other sustainable design measures	**$0-$4.50**
	Property Value	The appraised property value of a green roof is higher than the same building without the green roof, capturing the increased annual income flows as well as more favorable press and higher rental rates	**$12-$60**
	Occupant Comfort	A green roof positively affects occupant comfort through temperature moderation and an appealing aesthetic-this in turn can increase worker productivity	**Unquantified**
Currently Unincentivized			
	Urban Heat Island Reduction	The green roof retains less heat than typical concrete or asphalt rooftops in urban areas, decreasing the effect known as the urban heat island	-
	Air Quality Purification	Green roof grasses and shrubbery reduce the concentration of air pollutants in surrounding areas, which are typically worse in urban areas	-

In addition, the substrate with the plant material outperforms just the substrate material suggesting that cooling potential for a green roof lies in the vegetation. One theory postulates that "the dominant way for green roofs to dissipate the absorbed heat [is] evapotranspiration" (Feng et al. 959). Living plants transpire water through the stomata to cycle water throughout the plant and provide essential minerals and nutrients to various parts of its structure. In the process, the plant is cooled through the evaporation of water much as a person sweats to cool off his or her core temperature. Because of this, areas around plants are much cooler than un-vegetated ground of a similar material. Through this process of transpiration, roofs with plants are significantly cooler than those without them. In addition, plants reduce the albedo of the roof, meaning they reflect more light than roofs of concrete or asphalt.

The cooling benefit of a green roof provides an economic benefit by reducing energy costs towards heating and cooling. Green roofs tend to provide the most benefit to buildings that are "uninsulated or moderately insulated" (D'orazio et al. 440). Pre-existing effective layers of insulation tend to provide the same benefit in reducing cooling load, at which point adding an additional vegetated layer provides a negligible marginal benefit. One study found that during the summer period, a well-insulated building yielded basically 0% in energy savings with the addition of a green roof, while a green roof reduced energy use by 54%-61% in the same time frame for a building with no insulation (Niachou et al. 726). Older buildings will typically feature less insulation than new buildings as technology and building standards have evolved to put more emphasis on reduced need for heating and cooling. Therefore, the green roof will have a greater energy reduction when implemented for retrofit than for new construction. Holding the other insulation constant, the water content and substrate depth of the green roof material can have significant effects in changing how effective it is in energy performance. Because of "building weight restrictions and implantation costs" extensive green roofs are much more common than intensive green roofs (Getter et al. 3549). Shallow growing media cannot insulate the building as effectively as a deeper substrate. In addition, the shallow substrate can't support as deep of root systems limiting the size of plants grown. Deeper media "would allow the use of plants with greater biomass and leaf area, which in turn would lead to higher evapotranspiration rates" (Getter et al. 3557). In addition, the water content of the substrate

material can impact the green roof's effectiveness. If it is lacking water, not only will the plants grow less, the substrate will not absorb radiated heat as well (Zinzi & Agnoli 79).

For a business, the only real regard as to the energy performance of a green roof is how much it can actually reduce their energy bill. Along with absorbing radiated heat, the green roof acts like a winter hat on a human's head, keeping heat from flowing out the top of the building during the wintertime. The magnitude of these two effects is extremely dependent on the surrounding environment. The hotter the climate during the summer and the colder the climate during the winter, the more effective the green roof will be in reducing energy costs. In one study, the green roof was compared to a metal clad roof and unsurprisingly the contrast was stark. The green roof reduced the incoming heat gain by 97% and reduced the outgoing heat loss by 49% for a total yearly energy savings of 52% (D'Orazio et al. 440). Other studies have found differing results in the effectiveness of the same material based on the location and therefore climate surrounding the building. A green roof in Barcelona helps insulate in the winter but has little cooling effect in the summer leading to an energy reduction of only 14%. In comparison, the hotter Cairo climate, which used the green roof more to limit the cooling demand, resulted in 45% in energy savings (D'Orazio et al.). Another study compared a green roof scenario in Athens, where the energy savings through the hot and cold seasons amounted to 49% against one in Sacramento where the cooler temperate climate reduced the effectiveness of the green roof to 35% in energy savings (Zinzi & Agnoli). Aside from the surrounding climate, the specifics of the building also play heavily into the energy savings from a green roof. As previously discussed, the amount of existing insulation is key in determining the effectiveness of the green roof. In addition, green roofs will be significantly more effective in reducing energy costs of buildings with fewer floors. In any building, the heat gain or loss through the roof most significantly affects the top floor of the building. Therefore, adjusting the roof composition will affect one level buildings more significantly than multi-level buildings, where heat is gained and lost through the walls in greater proportion as the number of levels increases. In one study, the top floor alone reduced electricity consumption in the form of heating and cooling between 12-87% over the course of the year while the building overall was only reduced by 6-19% (Lin et al. 27). While reductions on the order of 20% are still beneficial to building owners and tenants, the green roof is a much more attractive option financially when the building is only one story and energy savings are maximized.

Even while there's debate on exactly how much energy can be saved through green roofs in buildings today, researchers agree that the future of green roofs for improving energy performance

is only getting brighter. On one hand, energy prices continue to rise due to increasing scarcity, which will make the reduction in heating and cooling more attractive to businesses (Energy Agency). Additionally, reducing energy use provides certain societal benefits. The production of electricity generates local and global pollutants through coal-fired burning, natural gas extraction and burning, and even renewable resource use (Proops et al.). As society becomes more aware of the negative effects of these pollutants, measures to reduce energy use will become publicly incentivized, capturing those societal benefits for the private business implementing the green roof. Similarly, green roofs help mitigate the effects of air pollutants by scrubbing particulates such as nitrates and sequestering carbon from the atmosphere (Binachini & Hewage, "How 'green' are the green roofs?" 59). Though the effect is small compared to the scope of the total problem, over time "carbon and nitrate credits" are predicted to "become much more robust" (Bianchi Hewage, "Probabilistic social cost-benefit analysis" 160). This will further improve the value to a business of installing a green roof.

Rooftops in urban areas also cause problems in terms of sunlight and heat absorption beyond the energy needed to cool the building on which they lie. The increasing amount of paved space in cities has led to increasing urban temperatures in an effect dubbed the "Urban Heat Island" (Zinzi & Agnoli 66). Roof surface in most cities "accounts for 20-25% of the total urban surfaces," and therefore has the potential "to reduce the air and surface temperature of the urban area," if addressed through a measure like a green roof (Zinzi & Agnoli 66). One study estimates that adding 10 per cent green cover to town centers and high-density residential areas that typically feature little green space can keep surface temperatures below 1960's baseline measurements (Gill et al. 122). While municipalities haven't yet shown an interest in subsidizing buildings that reduce the Urban Heat Island effect, it represents an aspect of green roofs that has the potential to add value to a building.

In most previous green roof academic research, the most valuable environmental aspect of a green roof is its ability to reduce stormwater runoff. When it rains or snows, the precipitation inevitably finds its way into the city's storm sewage system or directly into a waterway. On its way to its final location, stormwater will traverse many aspects of the built environment starting with rooftops, moving through gutters, along streets and finally through storm drains into sewage systems. Those areas of the built environment–streets in particular–collect nutrients, chemical deposits, and heavy metal ions. As the stormwater washes over them, the particulates are collected and taken straight to the waterway (Vanwoert et al., "Green Roof Stormwater Retention" 1036). Without treatment these chemicals and nutrients can make natural water sources undrinkable in addition to harming

natural ecosystems through eutrophication and "resulting loss of aquatic species" (Getter & Rowe, "The Role of Extensive Green Roofs" 1276). When untreated, the "quality of urban runoff water [approaches] that of treated sewage water or even worse" (Getter & Rowe, "The Role of Extensive Green Roofs"). When cities aren't equipped to treat stormwater runoff, they'll often implement measures to try and limit the total runoff volume. Even in cities where runoff is treated, a few times a year massive precipitation events overflow the treatment capacity and result in untreated water hitting waterways. In New York these massive precipitation events result in "40 billion gallons of untreated waste-water" into surface waters annually (Getter & Rowe, "The Role of Extensive Green Roofs" 1276). Cities are the main perpetrators of runoff problems; in forested areas roughly 95% of rainfall is absorbed compared to roughly 25% for a typical city block (Vanwoert et al., "Green Roof Stormwater Retention" 1036) (Getter & Rowe, "The Role of Extensive Green Roofs" 1276). Installing green roofs in urban areas has the potential to greatly reduce urban runoff problems.

As in the case of green roofs improving energy performance, the literature on reducing runoff has found mixed results but in each case the amount of runoff was reduced significantly. On the low end, the green roofs tend to retain about 60% of runoff all the way up to 100% retention dependent on the specific characteristics of the roof (Getter & Rowe, "The Role of Extensive Green Roofs" 1278). That compares to 27.2% retention for a gravel ballast roof and 50.4% for growing media absent any vegetation (Vanwoert et al., "Green Roof Stormwater Retention" 1040). The difference between the low end of 60% retention and the maximum of 100% can mostly

Stormwater runoff is a serious concern for cities as the water often contains hazardous pollutants like this dirty runoff in Iowa.

be explained through the depth of medium and slope of the roof. For flat roofs a medium depth of at least 10cm is necessary for the green roof to be effective (Vanwoert et al., "Green Roof Stormwater Retention" 1043). As the slope of the roof increases, the substrate depth must be increased proportionally as well to be equally as effective (Vanwoert et al., "Green Roof Stormwater Retention" 1041). Many studies have suggested that the vegetation in and of itself isn't incredibly important in runoff retention and that the majority of rainwater is stored within the growing media itself. However, without vegetation, the growing media might dissipate and lose its effectiveness, which results in the higher retention rate from vegetated media (Vanwoert et al., "Green Roof Stormwater Retention" 1044).

In determining how beneficial a green roof will be in terms of stormwater retention for a business, the first step is understanding how the local climate will play into the effectiveness of the roof. In areas with high rates of runoff, there are often tax incentives in place to capture the societal benefit of reducing that runoff. In New York, for example, a reduction in runoff can result in a tax reduction up to $4.50 per square foot dependent on the effectiveness of the roof (Bianchini & Hewage, "Probabilistic Social Cost-Benefit"). Other municipalities might also have a blanket impervious space tax, which levies fees on property owners for the amount of impervious space such as parking lots and asphalt roofs on their property. In that case, the introduction of a green roof will reduce the monthly tax that goes to the city's efforts to treat stormwater. Even more importantly, the implementation of a green roof can "positively affect the drainage system and drainage capacity of buildings" (Bianchini Hewage, "Probabilistic social cost-benefit" 154). Any rainwater landing on a building's property must be properly handled and relayed to the municipality stormwater system in accordance with city building codes. In new construction, a building designer can eliminate 30%-60% of stormwater infrastructure if a green roof is installed. This not only saves the materials necessary for that infrastructure but the construction labor as well. The exact savings is highly dependent on the complexity needed due to the location of stormwater drains, building codes and local climate.

In addition to these environmental benefits, green roofs are beneficial to business owners and tenants in improving occupant comfort. Two different behavioral hypotheses try to explain how sustainable design in general might affect occupant attitudes. The arousal hypothesis "predicts optimum satisfaction and performance [of occupants] under the conditions of moderate arousal" which in this case refer to adequate temperature, sound, and lighting (Paul & Taylor, 1859). The overload hypothesis, on the other hand, "assumes that humans have a finite capacity for processing stimuli

and information" and stimuli above that threshold causes people to selectively attend to information and ignore low priority inputs (Paul & Taylor, 1859). It's often assumed that a building designed with sustainability in mind will perform better on these key metrics of temperature, sound, and lighting and therefore result in greater satisfaction with the workplace environment. "Satisfaction with the workplace environment", in turn, has been linked to greater productivity and output for firms (Paul & Taylor, 1865). It's difficult to measure this impact, as there have been no large-scale studies of sustainable design affecting workplace productivity. Being conservative, it's safe to assume that at a minimum, the presence of the green roof won't decrease productivity only keep it the same.

Whereas researchers have yet to come to a strict conclusion on how sustainable design affects occupant comfort, authors are strongly conclusive to the argument that green or sustainable design improves property value. The only question is how much a green roof could improve value. The value of the building increases with a green roof, as the occupants will realize certain benefits previously discussed such as reduced energy cost and runoff taxes. In addition, there's a higher demand for buildings with a green roof because of increased occupant comfort as well as aesthetic value. While there isn't a great amount of data on property value fluctuation with green roofs, certain studies have used the increased valuation of property near woodlands and greenery as a proxy for how a green roof would affect value. Based on that estimation, the authors argue, "Extensive green roofs could increase property prices by between 2% and 5%. While intensive green roofs increase may vary between 10% and 20%" (Bianchini & Hewage "Probabilistic social cost-benefit", 154). Another framework based on existing sustainable design data estimates that green roofs might increase value between $12-$16 per sq. ft. for extensive roofs and $16-$60 per sq. ft. for intensive roofs. The large range for intensive roofs is a result of the most intensive roof scenario with a very high substrate depth and the ability to grow vegetables and herbs, which will seriously increase demand but also come at a high cost (Bianchini Hewage "Probabilistic social cost-benefit" 156). Also taken into consideration in valuation of green roofs is the affect on the roofing membrane, which normally is replaced every 10-15 years. With substrate and vegetation layered on top of the membrane, the increased moderation in temperature can "extend the membrane life two to three times" (Getter & Rowe, "The Role of Extensive Green Roofs" 1279). Previous benefits discussed are mostly realized by building tenants as opposed to building owners, which makes property value important. In cases where the tenants are not the owners, which is most shopping centers and movie theaters, there must

be incentives for the owners as well as the tenants in installing a green roof. Property value offers one such benefit to building owners.

Another way to look at the value of green roofs is within certification schemes such as the LEED (Leadership in Energy and Environmental Design) rating system (Getter & Rowe, "The Role of Extensive Green Roofs" 1280). A "quality green roof design" can earn a building as many as 15 LEED credits in the "categories of sustainable sites, water efficiency, and energy and atmosphere" (Kula 2005). A study conducted in 2012 found that on average, "homes labeled by Energy Star, LEED for Homes and GreenPoint Rated sell for 9 percent more than comparable, non-labeled homes" (Kok 3). While there isn't a direct way of translating this data into a forecast for commercial property, it demonstrates the existing societal mechanisms that give an economic benefit to environmentally rated property. Angie Fyfe, the executive director of the US Green Building Council's Colorado chapter (the organization that oversees LEED development) has found an increasing demand for LEED certified buildings in the past decade (Fyfe). In 2005, only 2% of new construction was considered "green building" while that number has risen to about 44% in 2012 ("Colorado LEED Projects 2002-2012").

One factor pervasive in the various economic benefits of a green roof is the importance climate plays in predicting environmental outcomes. Specifically with stormwater reduction and energy use mitigation, the green roof will be most effective at the extremes. For a climate with heavy rainfall, the green roof is incredibly important in reducing the amount of stormwater runoff that makes its way into storm sewers. For areas of little rainfall as well, damaging water borne pollutants are less diluted and therefore more dangerous for human and ecosystem health (NPDES Permits & Stormwater, "Stormwater Runoff"). Similarly, a green roof is most effective in reducing heating and cooling energy use in climates that feature drastically high and low temperatures. Comparatively, a more temperate coastal climate will have less change in temperature and therefore the green roof will be less beneficial. This does not mean that the green roof will be definitely profitable in harsh climates and definitely unprofitable in moderate climates, rather that each case requires individual attention and forecasting for the environmental benefits of the green roof.

Even with that concession, there are numerous environmental benefits to implementing a green roof. With those environmental benefits come economic benefits to the owner or tenant of the property that make a green roof a viable for-profit business initiative.

Aerial view of Westlake Shopping Center in San Francisco

Shopping Center Economics

CONSUMERISM AND SHOPPING have always played important roles in American culture. In the early 1900's, retail began consolidation from small specialty stores to large retail distributors servicing multiple needs. Department stores such as Macy's and Wanamaker's became mainstays in urban centers. Rather than shop from store to store along Main Street, consumers could now go to a single all-in-one store. After World War II, Americans began moving en masse to the suburbs and so did mass retailing in the form of shopping centers (Sternlieb & Hughes 64). However, retail shops on Main Street were more than "just commercially driven venues; they were the center of town life" (Sternlieb & Hughes 63). Therefore, when suburban shopping centers became the norm for retail purchases, they had to encompass the community life as well. Key to the development of that community life was a space where consumers could walk in between stores safely and undisturbed by automobiles. Stemming from the grassy national mall in Washington D.C., a mall is by its definition, "any parklike promenade or pedestrian zone" (Cohen 9). In both enclosed and outdoor malls there exists a space in between shops that allows consumers to walk safely and allows for a community space. In the late 90's the mall was "the place where one [could] go if one live[d] in the suburbs" to meet friends (Sternlieb & Hughes 247). It's thus that the mall has become an "integral element in the 'collective consciousness' of Americans" (Scharoun 67).

While the quintessential vision of a shopping center in America is an enclosed space spanning multiple acres, there are several different types of retail centers with different economic profiles and possibilities of including green roofs. Neighborhood centers are the smallest of the four categories spanning between 30,000 and 150,000 square feet of retail space with a target customer area of two miles. Neighborhood centers are

common fixtures in suburban areas. They usually feature a supermarket as the main anchor with fast food retailers or small specialty shops surrounding it. Community centers are the next largest type of center, covering between 100,000 and 150,000 square feet. Community centers feature several independent large anchor stores such as supermarkets, drug stores, home improvement centers, furniture retailers, or junior department stores. As a larger fixture, they're less common than neighborhood centers and thus pull from a larger consumer radius. The next largest designation is the regional center, often referred to as a regional mall. Their main customer radius is between 5-15 miles, and they span between 400,000 and 800,000 square feet. Regional malls are often enclosed with large pedestrian zones. Along with department stores, they feature a variety of fashion apparel stores and other specific interest retailers. Superregional centers are very similar to regional centers but are larger with Mall of America, the largest enclosed mall in the United States, featuring 2,500,000 sq. ft. of retail space. By their very nature, they include a much larger variety of specialty stores and fashion retailers. A study in 2001 found that 97 percent of shopping centers were designated as "strip malls," a colloquial term that designates a lack of indoor or outdoor pedestrian zone. At that time, there were only 1,200 regional or superregional malls. Intuitively this makes sense; given the vast consumer radius for each large mall, there's no need to have multiple malls within that radius as opposed to smaller "strip malls" that only serve a small radius and are thus much more prevalent (Cohen).

Malls were an innovation preferred over previous retailing models partly because they were "planned, developed, owned, and managed as a single property" (Cohen 9). This gave certain economic advantages in scaling security, property management, utilities, and maintenance. However, it also necessitated a rent structure different than previous commercial retailers, which has important implications for the institution of environmental measures. During the construction phase of a mall, the property owners will begin seeking rental agreements for future tenants. The first and most important retailers are often the large department stores that anchor the project. Owners will negotiate agreements with between two and five department stores based on the projected size of the mall. These stores represent one of the main draws to the mall once its operational and therefore have significant input into the construction and development processes. Often, department stores will own the land on which their building and parking areas are to be constructed.. In that case they'll be present in discussions before any construction is performed. These major tenants are very cost conscious in development and will often be inclined towards projects with lower ongoing maintenance and upkeep (Draper). As majority stakeholders in the mall and owners, they don't pass on revenues to the owners of the rest of the mall but may still pay for services such as security and maintenance

for the sake of simplicity. During that construction time, the owners will negotiate rental agreements with smaller tenants so that when the mall is finished it can be opened as soon as possible. Typically, the rent contract is made up of a guaranteed minimum element along with a percent of sales element. The guaranteed element helps the owner reclaim funds dispensed in construction while the continued percent of sales element compensates the owner for the value of the space. In addition, costs to the owner such as utilities, property maintenance, and taxes are passed on to the tenant. From these contracts, the owners' profit is the combined guaranteed element and percent of sales element less payments on any loans taken in construction and development. The tenants' profits are sales above and beyond the minimum element, percent element, and passed on direct costs. With increasing costs of "common-area maintenance and all of the HVAC," the directly charged costs to tenants can escalate to 50% of the total lease (Sternlieb & Hughes 250). Therefore, any action, such as a green roof, that can reduce the costs of maintenance, heating, and cooling will reduce the cost to the tenant. It's also attractive to the owner; however, because they can seek a greater percentage of ongoing sales while the tenant can remain profitable.

The profitability of green roofs partly depends on the increased shopping revenues ascertained through rebranding the shopping center as sustainable. As such, the mechanisms typical malls use to forecast profits are critical. Before construction, there are several important measures in siting decisions to maximize profits. One study of a typical shopping mall found that 82% of shoppers from the primary radius of the center were Caucasian with a college or post-graduate degree (Ardeshna 25). This isn't unique for shopping malls because they're typically located in suburban areas that feature these population characteristics. Mall owners will try to locate their property within more affluent areas where the average shopper will spend more per visit. In addition, the closer the mall is to the centers of population, the higher the sales.

Beyond siting decisions, mall owners take certain steps to maximize profits. While they can't change the products being sold at the individual retailers, they can encourage customer retention and loyalty. The pedestrian zone that makes a mall a unique fixture for retailing is also the aspect most controllable by the mall owners. Especially in large spaces, retaining the "smaller lifestyle center feel" can maintain consumer loyalty in the face of competitors (Ardeshna 25). In the past few years, with the economy in recession, shopping has decreased. There isn't enough total shopping revenue for all retailers to remain profitable; therefore, it's important to have "the dominant project in a market" to be sure that consumers choose your mall among others (Cohen 143). Internet-based shopping has

often been regarded as a detriment to brick and mortar sales for retailers, but in fact it has had certain unprecedented effects. It has decreased some in-store retailing by providing a substitute option but has also increased in-store retailing for some stores. Specifically, the option to buy online and pick up in a store has led to increases in sales on-site as customers have another avenue for being brought to the physical location (Kellogg Insight). Therefore, it's important to focus on brick and mortar retailing for the future, as online shopping has not yet shown the capacity to push it out of business.

Projecting future sales is a necessity for mall owners in negotiating leasing contracts, so they've developed certain metrics to analyze markets before any steel hits the ground. One of the primary indicators of a successful shopping center is the ease of access and natural traffic in the area. If more cars are consistently passing the shopping center on a daily commute, it's significantly more likely they'll stop and shop. However, if there's too much congestion in and around the shopping center, it can hurt sales figures because residents from farther away won't find it as economical to travel to the center. Similarly, if there are any physical barriers on any side of the mall such as undeveloped land, natural water features, or protected environmental areas, it will reduce the possible traffic and access to the site. Lastly, area residents are significantly less likely to shop across county or state lines. There are social and psychological barriers that promote shopping within one's neighborhood and condemn shopping far from home. This is why it's often more valuable for developers to locate in areas of high population density.

While the property owner will negotiate leases before construction is finished, there often remain unoccupied retail spots at the opening of the mall and, in certain cases, in perpetuity. These may be areas where tenants have recently vacated or less attractive locations with which the owner cannot attract new tenants. These areas represent lost potential revenue to owners and thus, one of the goals in managing mall property is minimizing "unproductive footage" (Sternlieb & Hughes 8). It's often this goal that has led to mall owners licensing small kiosks in the pedestrian areas to turn excess walking space into productive retail space. Consumers also tend to take "major issue with the appearance of dead and inactive spaces" (Urano et al. 585). It's therefore the role of the mall owner to create space around and in-between specific retailers that is as "good and appealing" as possible (Urano et al. 585). Customers are significantly more likely to linger in areas that are comfortable and aesthetically pleasing. Especially nowadays, many shoppers have "a list of items to pick up; they go on a specific mission to a specific store" with shopping declining as a recreational activity (Cohen 114). Anytime that the mall can encourage customers to stay and venture into other shops, they'll

increase the amount spent per visit. Certain mall owners have found that "fountains, benches" and other aesthetic upgrades to the pedestrian zone encourage the lingering that results in "more people for more hours" (Cohen 31). Partly, these amenities help replicate the feeling of a natural environment inside the enclosed mall. When customers enter the mall they're making an implicit choice between spending time in an indoor area, within the built environment, and being immersed in the natural outdoors. The effect is more subtle for neighborhood and community centers which typically don't have as developed of a pedestrian zone. However, incorporating some type of pedestrian zone has become more prominent in small-scale shopping centers as designers have looked to replicate the security and comfort of a larger mall on a smaller property. Providing a natural feeling, synthetic as it may be, can assuage the guilt of hours spent indoors.

For these reasons, mall owners are constantly looking for ways to improve their facilities. In that decision process, they mainly consider the return on cost to determine "if a project's increased incremental stabilized return will be acceptable or not" (Ardeshna 35). To measure the benefit of the improvements, owners calculate the capitalization rate: the annual increase in revenue divided by the total cost of the project. Typically, owners can sell malls at a 6.5-7% capitalization rate, meaning the property is valued around 14 times the current annual revenue. Therefore, any improvement project with a capitalization rate exceeding that 7% will be profitable for the owner in regards to the value of the mall. Retrofitting existing malls for these improvements can be labor and time intensive. Therefore, in past eras of "easy money," when owners were easily able to seek financing and lending for large construction projects, new growth was more popular (Sternlieb & Hughes 8).

When mall owners do choose retrofitting over new construction, environmentally conscious design has become more important over time. With the passing of the Clean Air and Water Acts in the 1970's, the shopping mall became recognized as an indirect threat to the environment. Unlike coal burning power plants or certain industrial processes, shopping centers are not a threat because of their direct emissions. However, they do "cause a significant amount of pollution through the excessive use of automobiles." The large parking areas utilized by concentrated shopping areas enabled customers to conveniently travel by automobile and with that necessitate "widening of roads and the creation of new ones to service these centers" (Scharoun 97). The shopping mall develops a sort of "auto-dependency" within the American public that does directly affect air quality. With the Environmental Protection Agency citing the shopping mall as a problem in the United States, mall owners were pressured to incorporate environmental concern into design and operations. As the public

attitude changed in the 1970's and 1980's, there was also pressure on mall owners to have a degree of environmental aesthetic incorporated into the shopping experience. Even still today, "the possibility of being reunited with nature, while ostensibly shopping, continues to attract" customers (Scharoun 101). In a 1999 study of mall going tendencies, researchers found that greenery and a more general aesthetic feel were hugely important to customer satisfaction. Second only to the quality of window displays, ongoing maintenance and presence of plants most affected the appearance of a shopping mall to consumers, thereby increasing their satisfaction with the shopping experience (Oppewal 59).

However, the synthetic natural environment developed in enclosed malls has begun to "affect the visitor in negative ways," rather than reunite consumers with nature as hoped (Scharoun 113). This is partly a reflection on the normalcy of mall space in America; consumers are used to the enclosed mall and no longer find its appeals enticing. In response, mall developers have returned to outdoor lifestyle centers- essentially malls with the roof removed. Rather than "vaguely evoking a town center," as enclosed malls frequently do, outdoor centers are actually done up to look like town centers, with urban grid patterns, cobblestone streets and outdoor street lamps. Municipalities try to encourage the natural environmental feel by promoting mixed-use development. In mixed use zoning, office and residential spaces are constructed on a second level above retail stores. Mixed-use development is often considered to give a more "nice, inviting environment" for people to want to stay and continue to visit (Cohen, 143). In addition, it eliminates part of the need for parking spaces and auto-dependency as the consumers live within walking distance of the shops. While giving the consumers the environmental feeling they yearn for, it also produces positive environmental outcomes by reducing automobile use.

In the past century, the mall has become an icon of American consumerism and daily life. Coming out of the early 2000's recession, shopping centers have struggled to stay afoot, with many closing due to decreased revenues. With that in mind, shopping center owners and tenants will look to differentiate from their competition and thereby stay in business. Specifically small and medium shopping centers will have the potential to become more profitable in the future through the implementation of environmental features that give them a comparative advantage.

Green Circle Shopping Center in Springfield Missouri

Shopping Center Green Roof Business Plan

-Executive Summary

The installation of a green roof on a shopping center is an uncommon but highly beneficial project in profitable sustainability. The green roof does come at a high construction cost, but results in environmental benefits that directly translate to business benefits. This reduces the payback period to a reasonable time frame of less than five years. Improved technology in the past decade has made the green roof less costly to implement and more environmentally efficient; at the same time electricity costs are rising and stormwater regulation is becoming more stringent. In addition, interest rates are at historic lows, allowing for less costly capital acquisition. Together these factors can turn what might have been a financially unsound project 10 years ago into a highly profitable endeavor today.

-Business Goals and Objectives

The business goals and objectives for this project focus on implementing a green roof to:

-Reduce energy use for the building
-Reduce and improve the quality of stormwater runoff
-Improve the average lifetime of the roofing membrane
-Promote a community gathering space
-Deliver competitive advantage to a shopping center
-Increase profitability through environmental benefit savings and increased customer base/loyalty

-Product and Service

For implementing on top of a shopping center, the best type of green roof is a semi-intensive design with at least 10 cm of substrate depth throughout and areas of deeper substrate depth mixed in,

allowing for produce and herb growth. Semi-intensive roofing is beneficial over extensive roofing because it allows for deeper rooting from vegetation, enabling the growth of plants on a perennial time scale which attracts customers and community members interested in farming. At the same time, the roof carries the environmental benefits of improved insulation and runoff retention.

Intensive green roofs also provide these benefits while allowing for the growth of vegetation with deeper root systems but require significantly more structural support due to the increased weight of the green roof. This not only makes the installation of the green roof more costly, it makes upkeep and maintenance less practical. For these reasons, a semi-intensive green roof is favorable to an extensive or intensive roof, providing the mixed solution of practicality and benefit to consumers.

The green roof should be designed to a ratio of 80 percent "shallow" substrate depth and 20 percent "deep" substrate depth, where shallow is between 8-10cm and deep is greater than 16cm. Designing a mixed system allows placement of intensive patches along pre-existing areas of stronger structural integrity, mitigating the need for increased structural amendments for retrofitted roofs.

The roof's ability to feature garden plots allows it to be a communal space, which is beneficial to the shopping center for many reasons. It gives patrons the opportunity to see firsthand the composition and structure of the roof, giving a tangible feeling to the rebranding of the center as sustainable. As a communal space, it can make the shopping center a gathering point for patrons as well as community members, thereby serving as a recreational area much like an urban green space. Finally, the garden plots afford the owners and tenants the ability to grow and harvest local produce, which can be sold at a farmer's market, featured in store fronts, or taken home by community volunteers.

In place of traditional drainage layers composed of well-graded soil or extracted and crushed rock, alternative new technology will be used such as chemically inert rubber tire crumbs. This increases the drainage capacity, improving the stormwater runoff benefit while reducing the weight of the substrate.

-Target building for implementation

The optimal shopping center for implementation of a green roof for economic benefit is a medium-sized neighborhood or community center. Smaller than regional and super regional malls,

neighborhood and community centers span 30,000 to 150,000 square feet drawing in customers from up to 7 miles. Featuring from one to three large anchor stores such as supermarkets, drug stores, home improvement centers, or junior department sores, these medium sized shopping centers are still a "one-stop-shop" for consumers despite not having an enclosed space like the larger regional centers. Often times, these shopping centers are referred to as strip malls due to their appearance as a set of retailers parallel to the road. The optimal shopping center will either be in the design stage or exist with plans for redevelopment. In both of these scenarios, cost of installation is less than for an existing shopping center with no plans to redevelop.

Medium sized centers offer an advantage over regional centers in implementing a green roof for a few reasons. For starters, regional malls are so large that attempting to cover the entire roof with a vegetative layer would be impractical based on the upfront cost and ongoing maintenance necessary. A solution to bypass that concern would be only installing vegetation on selective areas of the roof; however, that would change and in some ways diminish the environmental benefits of the planted roof. This is because some of the concrete or asphalt roof would be left uncovered and reduce the capacity of the green roof to mitigate energy use and stormwater runoff. For this reason, it's better to implement a green roof where the scope is such that the majority of the roof will be covered and therefore the environmental benefits are easier to predict. Even still, the green roof will likely be capped around 20,000 feet given a green roof larger than that would incur additional maintenance and risk concerns.

In addition, the number of retailers present in a regional mall provides certain difficulties in negotiating any contractual agreement that provides incentives for the property owner to install the green roof. While each individual retailer will have less bargaining power in a regional mall, collectively they have more ability to reject owner changes, such as a higher percentage of sales turned over to compensate the owner for the investment in the green roof. In addition, any peripheral services that require coordination among retailers, such as a farmers market or joint events, will be easier to organize from the perspective of a medium sized center. At the same time, a medium-sized center is beneficial as a place for implementation as compared to an individual retailer because of the scale afforded in the entire property being managed by a single owner.

Finally, there's more competition between medium-sized retailers than between regional centers. The size and scale of regional centers means that there are many fewer enclosed malls in the US than

the smaller "strip-malls." Because of this, consumers don't have the same degree of choice between regional malls. For many consumers, there are only two or fewer regional malls within close enough proximity to shop at regularly (Cohen). Comparatively, there might be several medium-sized shopping centers offering a choice in retail needs. For instance, within two miles of a consumer's home there might be substitute supermarkets or substitute home improvement centers. This allows consumers the opportunity to choose between centers. Therefore, if one can achieve a comparative advantage through the installation of a green roof, it can improve their profitability.

-Target costumer

Because of the possibility of comparative advantage, the shopping center can be rebranded through a green roof to target specific consumers. Neighborhood and community centers, targeting a more local radius of shoppers, are fairly specific to the demographics of their surrounding area. However, in general, the main shopping center consumers are in the middle to upper classes with disposable income to spend on consumer or luxury goods. These are also the consumers most prone to choose a retailer based on perceived sustainability. It holds, then, that shopping centers located in areas with middle to upper class consumers will be able to more fully reap the benefits of sustainability driven comparative advantage. In addition, teenagers provide an important customer base for shopping centers, using their communal space as a place for leisure beyond just shopping at the retailers. For this reason, teenagers are more prone to spend time at regional shopping centers because of the enclosed space. However, if a medium shopping center is designed with more of a communal space feel because of a green roof, it can provide a substitute attraction for teenagers. This would add a demographic to the shopping center's customer base, increasing profitability.

-Target Location

For the green roof to be a profitable investment for a shopping center, it must be sited in an area where the environmental benefits can be fully transformed into increased profit. Within this siting decision are two key variables: policy and climate. One of the key benefits of the green roof to the owner is an increased property value. That property value can serve as collateral for future capital loans and also guarantees a higher refinance or resale value. However, typically with increased property value comes increased property taxes. Fortunately, many states and municipalities offer property tax abatement for environmental improvements to a building ("Green Roof Legislation, Policies &

Tax Incentives"). New York City has the largest program in the country, providing tax abatements specifically for rooftop environmental upgrades such as photovoltaic solar panels and green roofs ("New York City-Property Tax Abatement for Photovoltaic Equipment Expenditures"). Nevada, Ohio, Maryland, and California all have similar programs spawned in the last 10 years. Through these policies, the owner can take full advantage of the property value increase to reduce the payback period of the green roof. For implementation immediately, the shopping center green roof will be most financially successful in states and municipalities with a similar program in place. However, this type of legislation is growing as a policy mechanism for encouraging green design. As such, it's likely to increase in prevalence around the country in the future, leading to more opportunities for profitable green roof installation.

The second important factor to take into account in green roof siting is the surrounding climate. In areas of a more moderate temperature range and precipitation level, the green roof will derive less economic benefit from the mitigation of runoff and energy use. Therefore, it will be most successfully implemented in areas that do have a harsher environment. Luckily, all the areas listed above with favorable legislation towards property tax abatement have climates in which a green roof can be economically beneficial.

-Comparative Advantage

A shopping center can derive a comparative advantage from installing a green roof through becoming a sustainable option in consumer shopping habits. In the past few decades, consumers have shown more and more of a tendency to prefer purchasing options that involve environmental and social sustainability. According to a 2013 Green America report, 75% of small business owners who sell "green products or service saw an increase" in the sales of those products from 2008-2011 ("The Big Green Opportunity for Small Business in the U.S." 12). The ability to differentiate among competitors led green small businesses in the past five years to achieve an advantage in their respective markets. The implementation of a green roof allows the shopping center to market its green and sustainable nature, which will increase annual revenues, as shoppers will choose the green center over rival centers.

From the perspective of the property owner, the green roof increases property value, decreases the need to re-roof, reduces the necessity of stormwater infrastructure and allows for greater contract

leverage with tenants. The tenant also benefits from the installation of a green roof, paying less in passed on utilities fees and increasing customer frequency. According to a green roof installation expert, the financial benefits in tandem with the recreational space provided are often the main motivations for an owner to pursue a green roof (Creath).

-Ongoing Operations and Maintenance

One of the benefits of a semi-intensive green roof is that the vast majority of the roof needs minimal maintenance. A roof-wide irrigation system installed at the time of implementation will lead to faster, fuller plant coverage, and less necessary maintenance throughout the course of the year. The extensive areas will need checkups two to three times per year, much like a lawn sprinkler system. These are necessary to ensure proper irrigation functioning (including blowing out the system in the winter) and repairing any minor roof membrane problems. This maintenance is best done by a green roof professional such as a staff member from the installation company.

The intensive parts of the green roof require more day-to-day maintenance including watering, weeding, and seeding or harvesting of plants. In the majority of community garden systems in the US, regular garden tasks are performed by a combination of community volunteers and garden staff members. For the shopping center green roof, a staff member could perform routine maintenance service for a short amount of time weekly. However, it's unrealistic for the maintenance to be performed solely by a staff member due to the high cost the shopping center would incur. For this reason, it's important to establish community demand for the garden before implementation to ensure there will be ample volunteer support to maintain the garden plots.

If the shopping center does find decreasing demand over time to maintain the garden, the intensive plots could be shifted to feature a low-maintenance grass such as Sedum, turning the green roof from a semi-intensive roof to a fully extensive roof. While this does change the nature of the roof and the periphery services associated with growing produce or vegetables, it allows the shopping center to retain the environmental benefits of the roof without needing excessive staff time to maintain it.

One of the benefits of a semi-intensive roof is that there are opportunities afforded to the shopping center in growing produce and vegetables on site. For example, the shopping center could host a community farmer's market on weekend mornings once or twice a month. This would bring

additional customers to the premises. If set up at a time when the shopping center has relatively little business, for instance early Sunday mornings, there would be excess space in the parking lot that could be used for the market. If the neighborhood already has a market established, moving it to the shopping center won't come at a significant cost. Establishing a new farmer's market, which would involve contacting local small farmers as well as putting together a framework and marketing the events would take a significant amount of work. Barring a community volunteer running the organization for the market, the shopping center would need to hire a staff member to work on the project for it to be a success. While a shopping center could establish a farmers market without installing a green roof, together they form a synergy for the shopping center by focusing community attention on the produce grown on site. Also, it would be a rare opportunity for an urban farmer's market to feature produce grown where it's sold.

Aside from running a farmer's market, a shopping center could harvest the produce grown on the roof and sell it at one of the retailers, providing a low-cost, organic source of vegetables and herbs. If the shopping center has a supermarket as an anchor, it provides a very natural selling point, yet even if they don't, a small section can be set up at another retailer to sell the produce. This would require slightly more logistical work but would still be a beneficial draw to the shopping center.

-Financing

Ranging from $5 to $60 per square foot, a green roof is a relatively expensive project for a shopping center to implement compared to what might be considered in the same vein, replacing the HVAC unit, which would cost between $1.50 and $2.00 per sq. ft. (Sink). For this reason, it will be more beneficial for a shopping center to consider implementing a green roof during an already planned re-development or before new construction. At either of these points, the marginal cost of installing the green roof will be less than in the case of a direct retrofit where any necessary structural re-adjustment will not only be more expensive but also require interruption of retailers' normal operations.

As with any large investment, the shopping center can minimize payback time by paying in cash out of pocket, which won't require paying interest on any loans taken. If the center is unable to pay upfront, there are financial assistance options on a federal and municipal level specific to environmentally beneficial improvements. These government secured loans are specially suited to projects such as green roofs, havings lower-interest rates or special structuring to incentivize green design

projects. One such option is property secured loans such as the California PACE program, which ties the cost of improvement to the property value of the building. This allows owners or tenants to pay back the loan using the reduced energy bills or taxes resulting from the completed improvement. A full listing of government programs for grants and other funding is available through the Environmental Protection Agency at http://www.epa.gov/home/grants-and-other-funding opportunities. In addition, the US small business administration has a directory and guide for environmental based funding at www.sba.gov/content/environmental-grants-loans.

Regardless of whether the project is internally or externally funded, the shopping center should pursue grant awards given out both federally and locally for innovative environmental design. Even as green roofs are becoming more common in American society, they're an impressive sustainable design feature. Any grant secured will reduce the funding burden of the project, shortening the payback time. ("Funding for Green Roofs") Outside of grants, many municipalities provide tax relief or funding assistance at the time of implementation of a green roof, which can, again, reduce the funding burden and shorten payback time.

-Return on Investment

The payback period for the green roof project hinges on capturing the environmental benefits of the green roof and turning them into increased profit. At the time of implementation, the roof adds a property value to the building up to $25 per square foot, which is calculated as a combination of estimates on the value of extensive and intensive roofs (Bianchini & Hewage, "Probabalistic Social-Cost Benefit Analysis of Green Roofs" 154). To better estimate the exact property value increase for a shopping center I used an income approach to commercial real estate appraisal. In this method, the property value increase is a multiple of the increased annual income stream from improvements. The exact multiplier is dependent on what's called the capitalization rate, which is a ratio of net income to the property value of a project. Using industry standard capitalization rates allows projection of property value increase given an increase in net income.

In 2013, neighborhood shopping centers average a capitalization rate of 8% ("Cap Rate Survey: February 2013" 19). The capitalization rate measures the rate at which income increases result in higher property value, with a lower capitalization rate indicating less improvement in property value for the same level of income increase. Therefore, with a capitalization rate of 8%, any annual net income increase will increase the property value by a factor of 12.5. That income, and the subsequent

property value increase will be detailed in the appendix. The property value increase is a one-time benefit added to the property and while it is based on the increase in annual net income from environmental and economic benefits, it is distinct from the two in this business plan because the owner, rather than the tenant, absorbs the value. The tenant directly receives the annual profit increases from the green roof while the owner doesn't see this benefit directly. However, the owner does receive certain tangible benefits from the property value increase such as asset growth, increased collateral in loans, or increased capital when the "property is refinanced or sold" ("The High Performance Portfolio, Rethinking Simple Payback Period" 3). For this reason, it's counted in addition to the annual net income benefits in payback period calculations. However, it's not counted in net present value calculations because it doesn't result in definitive future cash flows. The property value calculations assume that the green roof is constructed in a state or municipality where the environmental upgrade results in property tax abatement. As the prevalence of property tax abatement policies increases, the number of locations optimal for a green roof will also increase.

In addition, in the implementation of a green roof on new construction, there's a one-time cost avoided of installing stormwater infrastructure on the building. Since the green roof will retain the majority of stormwater, the designer will not need to include as much stormwater mitigating infrastructure such as drains, pipes, and sewer openings. Many states and municipalities offer incentives to construct a green roof and those tax abatements are estimated at a benefit of $2.25 per sq. ft. for this type of green roof. In addition to those one-time benefits, the green roof will provide ongoing economic value in reduced stormwater or impervious space taxes and reduced energy use for heating and cooling. These calculations assume a moderate climate for implementation of a green roof. In more temperate coastal climates, the implementation of a green roof will result in less beneficial environmental outcomes and therefore less direct profitability.

For new construction, the implementation of a green roof has a fairly wide range of possible payback time. Only including avoided costs from environmental benefits and therefore ignoring increased revenues from consumer choice in shopping centers, the green roof averages a payback period of 5.05 years. In the best-case scenario, the reduced need for stormwater infrastructure, municipal installation grant, and property value increase offsets the entire construction cost of $350,000 with over $200,000 in benefits remaining. Producing a positive net value in the first year after construction, the green roof is clearly a good project in this scenario. On the flip side; however, there is a possibility given these parameters that the green roof is an ongoing cost rather than a profitable endeavor. If the stormwater tax reduc-

Table 3: Shopping Center New Construction Payback Period

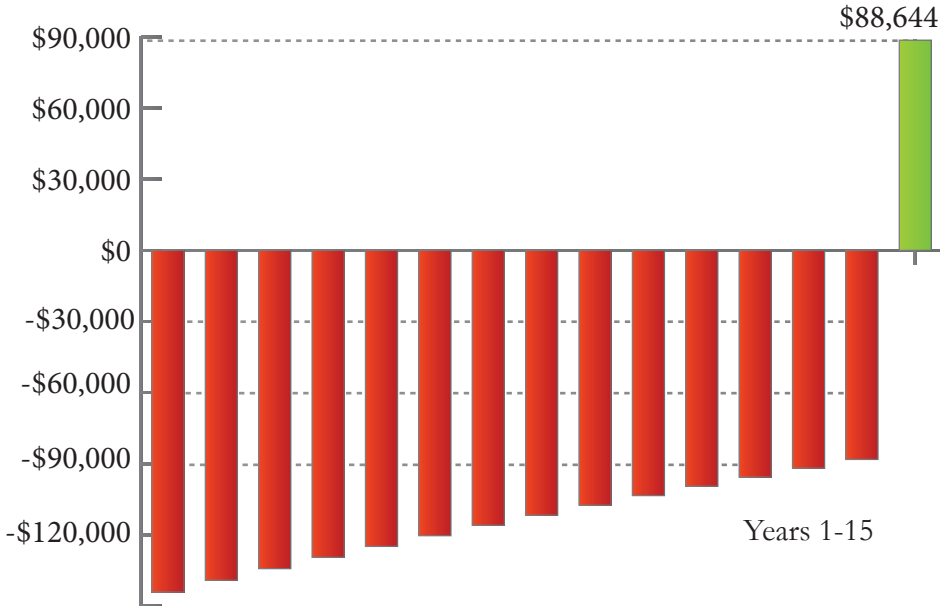
New Construction

Benefit	Time Scale	Benefit per sq. ft.	First Year	Subsequent Years
Grant/Tax Abatement	Once	$2.25	$45,000	-
Property Value Increase	Once	$6.43	$128,664	-
Reduced Stormwater Inf.	Once	$7.88	$155,750	-
Stormwater Tax Decrease	Annual	$0.39	$7,840	$7,840
HVAC Savings	Annual	$0.28	$5,625	$5,625
O & M costs	Annual	-$0.25	-$4,960	-$4,960
		Total	**$315,568**	**$8,505**

tion and HVAC savings are not high enough to offset the ongoing operations and maintenance costs, the green roof will not pay for itself. However, again, this situation doesn't take into account any increased customer revenue and relies on the absolute worst-case assumptions of the environmental benefits.

To calculate a 15-year net present value of the green roof for shopping center implementation, I used a discount rate of 4%. A 10-year treasury bill today would yield in the neighborhood of 2.75% while a 5-year bill would yield around 1.35%. The shopping center could invest the

Table 4:
Shopping Center New Construction
Net Present Value



capital necessary for the green roof in other projects to stimulate revenues at the shopping center and if no such opportunities arose, in safe bet treasury bills. Over the 15 years, the bills would accumulate nearly a 4% return. Using the 4% figure assumes that the shopping center doesn't have better opportunities to grow the capital. However, I found it better to be conservative than overly optimistic about the value. Discounting future cash flows of reduced energy use, stormwater tax reduction, as well as the one-time need to reroof resulted in a 15-year net present value of $88,644, which amounts to $4.43 per square foot of the roof.

Table 5: Shopping Center Retrofit Construction Payback Period

Retrofit Construction

Benefit	Time Scale	Benefit per sq. ft.	First Year	Subsequent Years
Grant/Tax Abatement	Once	$2.25	$45,000	-
Property Value Increase	Once	$20.55	$411,000	-
Stormwater Tax Decrease	Annual	$0.39	$7,840	$7,840
HVAC Savings	Annual	$1.50	$30,000	$30,000
O & M costs	Annual	-$0.25	-$4,960	-$4,960
		Total	**$315,568**	**$8,505**

The retrofit case of the green roof has a zero payback period, being profitable in the first year after construction. In most retrofit cases, some structural adjustments will need to be done to support the weight of the roof and the design process isn't as efficient as is the case with new design. This leads to a higher initial cost on the order of 20-40% (Castleton et al. 1589). However, the retrofit case does have a higher potential for annual environmental benefit as the increased energy reduction and stormwater avoidance provides direct economic benefits to the shopping center. The higher net income also results in a higher property value based on the income appraisal approach. The combined property value increase and municipal grant result in first year benefits of $456,000, significantly higher than the $400,000 initial cost. On top of that, the roof has annualized benefits of $33,880

from stormwater tax reduction and energy savings. With first year profitability, the retrofit green roof can greatly increase the profitability of a shopping center in perpetuity.

In the retrofit case, the net present value amounts to $116,954, which can be understood as $5.85 per square foot of roofing. Without additional shopping center revenues from customer choice, the retrofit case only achieves a positive net present value in year 15 when the avoided cost of re-roofing is absorbed by the center. This is despite the zero payback period because the net present value calculation doesn't take into account the property value increase, as it provides no direct cash flows.

The payback period of 5.05 years for a new construction green roof may be too long for a shopping center to consider it a viable investment. Lowering the payback period to two years would make it much more reasonable in the minds of owners and tenants by decreasing the time lapse before profitability. To decrease the payback period to two years, the center would have to achieve an additional $1,788 in profit annually. This would up the property value increase to $128,664 and change the net income in subsequent years to $10,293. $1,788 is not a significant amount given the scope of most small and medium-sized shopping centers, making the green roof a very realistic investment.

-Advertising and Marketing

In theory, the green roof will be marketed over time by word of mouth through shoppers and community volunteers. However, it will need an initial push to take hold as a means of rebranding the shopping center as sustainable. For a communally owned and managed center, the logo and physical imagery could be changed to reflect a greener building. In addition, pictures could be framed and hung on the exterior of the shopping center, showcasing the community volunteers working on the rooftop. Positioned next to storefronts, this would be a powerful way of connecting the environmental benefits of the building with its main function, retail shopping. Through a moderate advertising campaign, a shopping center can more fully reap the consumer preference benefits of incorporating sustainability.

AMC 25 movie theater in New York City, New York

Movie Theater Economics

Throughout the 20th century, movie theaters have been a staple of American culture and one of the most successful entertainment business models. Before television sets existed in households across the country, a movie theater was the only place to watch motion picture films (Vogel). The industry was established so that theaters could lease and "share" films being produced instead of purchasing them, which allowed for a rapid increase in the number and diversity of movies played in theaters (Litman 8). The culture of film production and exhibition led to the theater at the center of the community and to the popular American landmark of Hollywood. With the advent of VHS in the later 20th century, the movie industry transformed as Americans could now purchase movies and play them at home as opposed to attending a screening at a theater. Since that point in time, theater revenues have decreased as a percentage of total movie entertainment while home viewing has skyrocketed. Innovations continue with DVD, Blu-ray, Redbox, and Netflix becoming commonplace in the US. Even still, the movie theater industry is one of the largest in America with admissions in 2012 at 1.36 billion annually and box office revenues near $10.8 billion ("Domestic Movie Theatrical Market Summary 1995 to 2013"). As a massive piece of American culture, it will remain a core feature of the entertainment industry for many years to come.

The movie industry can generally be separated into three distinct phases: production, distribution, and exhibition. In the first stages of a movie, a producer or writer thinks of an idea for a screenplay. They pitch the idea to a distribution company, who can choose to invest in the idea and provide the initial capital to undergo development of the film. At this stage other producers join the team, hire actors, and begin filming. Once filming is done, the movie goes into post-production, where

a technical team edits the raw footage, adds graphical design, and the composer writes and records the score. Based on the complexity and scope of the movie, this stage can last from several months to a few years. Meanwhile, the distribution company begins working behind the scenes to secure contracts with exhibitors as well as market the movie to the public.

As the release date nears, the production team continues their role by marketing the movie through interviews and red-carpet events while the distributor-exhibitor contract details are finalized. Then the movie debuts in theaters and plays for the length of the contract.

The process of distribution, from negotiating contracts to marketing new releases, offers economies of scale that favor large national companies. This has therefore led to a few highly concentrated distribution companies owning a majority share of the business. Large, brand name companies such as Sony, Disney, 20th Century Fox, Paramount, and Warner Brothers dominate the industry, distributing films produced by smaller companies along with the ones they themselves produce.

Typically, there are three different types of movie exhibitors: traditional small theaters, large multiplex theaters, and alternative theaters that contain a bar or restaurant. Small theaters tend to be located in urban areas or strip malls and have fewer than 10 screens while multiplex theaters have become more popular as the density of population around US cities sprawled into suburban areas. Multiplexes feature more screens than small theaters, sometimes up to 30 in one building. As with distribution companies, a few large megaplex owners control the vast market share in the US. Together, Regal, AMC, Carmike, Cinemark USA, and Loews Cineplex account for roughly 25% of sites and 45% of screens in the US. (Eliashberg, Elberse & Leenders). Alternative theaters offer an interesting twist to the traditional theater business model by integrating a bar or restaurant along with 5-10 screens. Over the last two decades, these theaters have grown significantly in popularity as middle and upper class customers can purchase differentiation in the movie watching experience through food or drink service within the actual theater.

Food and drink play a crucial role in the business operations of movie theaters because of the theater exhibitors' profit model. Generally distributors use an "auction process to license films to theaters" (De Vany & Walls 784). Exhibitor bids typically follow one of two structures. The first type of bid, also the most common, is a 90-10 split over the house nut. The distributor and exhibitor negotiate and come to an agreement on the "house nut," the movie theater's operating cost

for showcasing a film which can include staffing, rent, and utilities. Above those operating costs, all box office revenue for a specific movie will be split with 90% returning to the distributor and 10% staying with the exhibitor as profit. The other common type of negotiation agreement is a minimum gross percentage. As opposed to the 90-10 split, a minimum gross percentage contract doesn't contain a flat fee to cover operating costs but rather has a sliding scale for the revenue split. Often, a minimum gross percentage contract will begin with 60% of revenues returned to the distributor and 40% retained by the exhibitor. Over the course of the film's run, the percentage returned to the distributor decreases (Moul 863).[1]

Distributor-exhibitor contracts also contain other clauses to protect the interests of both parties. Most movies will have a "minimum run" detailing the number of weeks that the exhibitor has to keep the movie playing. This shares the risk of film production. If a movie "flops" at the box office, the theater has to keep it playing for the length of the contract, unable to switch to a more profitable film. In this way, a "flop" hurts the distributor and the exhibitor. On the other side of the spectrum, the contract protects distributors if the box office sales exceed expectations. Contracts often include holdover and "best weeks" clauses for the benefit of the distributor. A holdover clause keeps the movie in theaters if it performs above a certain level while a "best weeks" clause has a higher distributor split if the movie attendance peaks in any week period after the opening week, for instance when a holiday weekend is several weeks into a movie's run (Switzer & Besocke 335).

In addition, contracts will often "clear" an area near the theater where the distributor cannot license the same film to other exhibitors. For a producer and distributor, the majority of costs occur before the physical distribution of the film to exhibitors. Once they begin the distribution, it's in their best interest to feature the movie at as many theaters as possible, as that will maximize their possible profits. However, if the movie is featured at several theaters within a small area, moviegoers will be split between the individual theaters and none of the theaters will make as great of a profit as if they were the only location offering that movie. By ensuring clearance in the contract, theaters protect themselves from losing revenue to competitors in the immediate vicinity.

Both the 90-10 and minimum gross percentage contract styles result in a movie theater returning the majority of box office revenue to the distribution company. Consequently, the profit per ticket

1 This decreasing sliding scale attempts to compensate exhibitors to continue showing movies as their weekly marginal revenue declines instead of using that screen for a newer movie that might draw more attendance to the theater.

sold is very low or nonexistent. The sole reason movie theaters remain in business today is a result of concession stand sales. Concession profits typically "vary from 30% to 40% of box-office revenue." (Swami, Eliashberg, & Weinberg). Concession products have very high profit margins compared to ticket sales. Theaters don't allow customers to bring in outside food or drink, so once they're inside, the theater has a monopoly over concessions. This results in relatively high prices for products that have very low variable costs. Popcorn, for example, requires only corn kernels, butter, and oil but may sell for $5.00 at a movie theater. Furthermore, the theater "retains 100% of all concession revenues" compared to the 10% retention of ticket sales revenue (Litman 50). Therefore, increasing concession revenues is key to increasing the profitability of a theater. Alternative independent theaters have the same reliance on food and drink sales for their profitability, though in their case it is at a bar or restaurant as opposed to a concession stand. Typically 40-60% of an alternative theater's revenue comes from the bar or restaurant (Rimoch). This revenue will also come at a higher profit margin than ticket sales, resulting in the majority of an alternative theater's profits derived from food and drink sales.

Concession revenues for both multiplex and independent theaters are proportional to theater attendance. Therefore, the theater can increase its concession profit by increasing attendance. There are three seasonal periods in which movie attendance is highest: Easter Weekend, summer months between memorial and labor day, and the time around Christmas and New Year's Day. Aside from holidays, weekends in general account for between 66% and 72% of total admissions (Moul 872). Friday night and Saturday night showings are by far the most popular in the week making up for weekday and weekend matinee showings that may only fill 5-10% of the seats. Overall, the theater will aim to fill at least 20% of seats over the course of a week with 25% considered very good in the industry (Rimoch). Since Friday and Saturday night showings will consistently almost sell out, theater owners need not focus on driving attendance to those shows. Instead, owners attempt to increase attendance through the week by focusing on weekday and matinee shows. Finding a way to draw a consistent audience during those time slots would give movie theaters a competitive advantage in negotiating contracts with distributors and increase the profitability of their day-to-day operations.

From an outside perspective, the movie theater industry may seem competitive; consumers choose between a number of theaters on any given night. In this respect, the competition is high between the major multiplex theaters, which each screen first-run movies. If a theater can differentiate itself among competitors, it can lure in additional customers, since those customers have a

choice. However, there's little competition outside of major movie exhibitors, since the four largest firms control nearly half of all screens. This is due to the combination of economies of scale and high barriers to entry. Large-scale exhibitors have deeply engrained relationships with distributors that lead to pseudo-guarantees on contracts and favorable terms. This isn't collusion per se as any such activity has been highly regulated since the 1948 *United States vs. Paramount Pictures Inc.* decision; it's simply a calculated decision on the part of distributors. Knowing that high profile exhibitors will have an easier time attracting customers, there's less risk in licensing movies to them. Therefore, distributors can license the film at a more favorable rate to the large exhibitor than they could small-scale exhibitors. Once a distributor licenses those movies, customers will naturally flock to the high profile, large exhibitors creating a positive feedback loop that's led to the competitive situation today. As a result, there's also a large divide between multiplex theaters and smaller independent theaters. Small independent theaters can't secure first-run movies if located within the clearing area of a multiplex that's negotiated a contract with a distributor. Even when they manage to secure a newly released film, the contracts will not be as favorable as those given to multiplexes because of the above risk reasoning. In this way, the movie industry is truly divided between large multiplexes and small independents, while multiplexes retain an economic advantage.

Moving from the macro-scale economics of the movie theater industry to the micro-scale, researchers have attempted to segment the movie theater audience into several different groups based on their motivations for attending movie screenings. There are three main groups that are important in the discussion of theater economics: the "apathetics," the "cinema buffs," and the "socials." Apathetics are so named because of the relaxed reasons why they attend movies. They often just go along with someone else rather than having any real desire to see a particular film. Demographically, they tend to be younger and more male than female. In addition, they don't go to the theater as frequently as the other audience segments. Apathetics are important to the theater business in their unimportance to the revenue model. Because of the difficulty in attracting them to the theater, owners spending money trying to bring them in is inefficient. Apathetic customers don't respond to typical marketing techniques and aren't drawn by the quality of the theater facility. As contradictory as it might seem, targeting these customers is more costly for a theater than it is beneficial.

The two other customer groups: the social goers and cinema buffs, form a significant portion of a theater's audience and have more specific motivations for attending. The social goers have "strong and diverse motives for going to the cinema" (Cuadrado & Frasquet 264). Movies serve as a form of

entertainment, a reason for "going out," or an opportunity to spend time with friends or a partner. Social goers are typically more "demanding in terms of cinema facilities and services," which also means they're more likely to be swayed into attending by upgraded facilities and services (Cuadrado & Frasquet 264). They're one of the more profitable segments to a movie theater because of their high propensity to spend on periphery services, whether that's concession items, upgraded tickets, or bar and restaurant service. The cinema buffs are aptly named, as their main driver for attending a movie is the film that the theater is showcasing. They may attend individually or as a group but are drawn almost solely because of the quality of movie. This means they are less particular about the facilities and services as they view the theater only as the receptacle where they can view a film. To the cinema buffs, the theater is not a social gathering point. Cinema buffs are important economically to the theater business because they tend to go more often than any other audience segment. In addition they are more likely to attend during the week when attendance is typically low, an important target for movie theaters looking to boost overall attendance (Cuadrado & Frasquet 264).

The economics of the movie theater industry provide an interesting starting point for a theater looking to boost profit. There are essentially two pathways to affecting the business model: increasing in-house revenue on periphery services or negotiating more favorable external contracts with distributors. In either case, the customer response is very important in determining how successful any theater venture will be. Altogether, the key to increased profit in the theater industry is initiatives following one of these two pathways with a keen understanding of how the specifics of the theater and audience will play into the business model.

Movie Theater Green Roof Business Plan

-Executive Summary

The installation of a green roof on a movie theater is an uncommon but highly beneficial project in profitable sustainability. The green roof does come at a high construction cost, but results in environmental benefits that directly translate to business benefits. This reduces the payback period to a reasonable time frame of less than 3.5 years. Increased attendance and peripheral revenue from re-branding as a sustainable theater benefits both the owners and tenants in the long term. Improved technology in the past decade has made the green roof less costly to implement and more environmentally efficient; at the same time electricity costs are rising and stormwater regulation is becoming more stringent. In addition, interest rates are at historic lows, allowing for less costly capital acquisition. Together these factors can turn what might have been a financially unsound project 10 years ago into a highly profitable endeavor today.

-Business goals and objectives

The business goals and objectives for this project focus on implementing a green roof to:

-Reduce energy use for the building
-Reduce and improve the quality of stormwater runoff
-Improve the average lifetime of the roofing membrane
-Promote a community gathering space
-Deliver competitive advantage to a movie theater
-Increase profitability through environmental benefit savings and increased customer base/loyalty

-Product and Service

For implementing on top of a movie theater, the best type of green roof is a semi-intensive design with at least 10 cm of substrate depth throughout and areas of deeper substrate depth allowing for herb and produce growth. Semi-intensive roofing is beneficial over extensive roofing because it allows for deeper rooting from vegetation, enabling the growth of plants on a perennial time scale which attracts customers and community members interested in farming. At the same time, the roof carries the environmental benefits of improved installation and runoff retention.

Intensive green roofs also provide these benefits while allowing for the growth of vegetation with deeper root systems but require significantly more structural support due to the increased weight of the green roof. This not only makes the installation of the green roof more costly, it makes upkeep and maintenance less practical. For these reasons, a semi-intensive green roof is favorable to an extensive or intensive roof, providing the mixed solution of practicality and benefit to consumers.

The green roof should be designed to a ratio of 80 percent "shallow" substrate depth and 20 percent "deep" substrate depth, where shallow is between 8-10cm and deep is greater than 16cm. Designing a mixed system allows placement of intensive patches along pre-existing areas of stronger structural integrity, mitigating the need for increased structural amendments for retrofitted roofs. These intensive patches can be sectioned into garden plots that can be maintained and planted by members of a community. This turns the green roof into what's commonly known as a community garden.

The roof's ability to feature garden plots allows it to be a communal space, which is beneficial to the theater for many reasons. It gives patrons the opportunity to see firsthand the composition and structure of the roof, giving a tangible feeling to the rebranding of the theater as sustainable. As a communal space, it can make the theater a gathering point for patrons as well as community members, thereby serving as a recreational area much like an urban green space. Finally, the garden plots afford the owners and tenants the ability to grow and harvest local produce, which can be sold at a farmer's market, featured at the bar and restaurant, or taken home by community volunteers.

In place of traditional drainage layers composed of well-graded soil or extracted and crushed rock, alternative new technology will be used such as chemically inert rubber tire crumbs. This increases

the drainage capacity, improving the stormwater runoff benefit while reducing the weight of the substrate.

-Target building for implementation

In order for the movie theater to benefit from the implementation of a green roof, the construction cost cannot be initially prohibitive and there must be the possibility for comparative advantage. For these reasons, a medium sized, independent theater with a bar or restaurant is the ideal candidate for a green roof.

These theaters, referred to as alternative independents, present a different business model than the typical multiplex theater. They derive a higher percentage of revenue from their periphery services such as bar service and restaurant sales, often charging less for tickets. With a smaller capacity than multiplex theaters, they have less bargaining power in negotiations with movie distributors and may be excluded from first run movie screenings if within the clearing area of a larger theater. Because of this, their rental fees for movies will be lower and the theater can charge less for tickets to break even, seeking to draw customers who will spend at the bar and restaurant, driving revenue for the theater overall.

This in turn transforms the theater into more than just a viewing house for showing movies; it's a community gathering point, a full night of entertainment, and a relaxing experience. This gives alternative independent theaters an advantage in implementing a green roof because it will heighten the characteristics of the theater, influencing the customers more than a green roof might on a multiplex.

An ideal alternative independent theater will have a roof around 10,000 square feet that is flat. Because of the high weight of green roof substrate, the building must have a load capacity capable of bearing the green roof without issue. Therefore, structural adjustment will be necessary if the roof isn't already rated for high weight. The movie theater will have to close temporarily for the structural readjustment; because of that, targeting new construction or a building already in a redevelopment cycle will be ideal.

-Target costumer

Because of the possibility of comparative advantage, the movie theater can be rebranded through a green roof to target specific customers. Alternative independent theaters tend to draw a crowd that is middle to upper class with income to spend on leisure and entertainment. These target customers tend to enjoy the "night out" experience of an alternative independent theater, spending a weekend night getting dinner and a movie or staying after a movie to grab drinks at the bar. The middle to upper income group is the most likely demographic to chose a consumer option based on green or sustainable features. (Murphy et al. 61) This leads to a greater comparative advantage for theaters that target these customers in the first place. In addition, alternative independents draw fewer teenagers and elderly customers than multiplexes, which gives the alternative independent theaters an opportunity to increase revenue if they can attract these customers through a green roof. Community garden plots most often attract those with free time during daylight hours. As a demographic, the elderly are more likely to have time to spend at a community garden, working less or not at all compared to full time employed younger adults. Similarly, teenagers tend to have more free time in daylight being in school fewer hours than a full time job demands. Attracting these customers through a green roof has the potential to provide a large increase to the theater's customer base since they were previously not as involved in the theater.

-Target Location

For the green roof to be a profitable investment for a movie theater, it must be sited in an area where the environmental benefits can be fully transformed into increased profit. Within this siting decision are two key variables: policy and climate. One of the key benefits of the green roof to the owner is an increased property value. That property value can serve as collateral for future capital loans and also guarantees a higher refinance or resale value. However, typically with increased property value comes increased property taxes. Fortunately, many states and municipalities offer property tax abatement for environmental improvements to a building ("Green Roof Legislation, Policies & Tax Incentives"). New York City has the largest program in the country, providing tax abatements specifically for rooftop environmental upgrades such as photovoltaic solar panels and green roofs ("New York City-Property Tax Abatement for Photovoltaic Equipment Expenditures"). Nevada, Ohio, Maryland, and California all have similar programs spawned in the last 10 years. Through these policies, the owner can take full advantage of the property value increase to reduce the payback

period of the green roof. For implementation immediately, the movie theater green roof will be most financially successful in states and municipalities with a similar program in place. However, this type of legislation is growing as a policy mechanism for encouraging green design. As such, it's likely to increase in prevalence around the country in the future, leading to more opportunities for profitable green roof installation.

The second important factor to take into account in green roof siting is the surrounding climate. In areas of a more moderate temperature range and precipitation level, the green roof will derive less economic benefit from the mitigation of runoff and energy use. Therefore, it will be most successfully implemented in areas that do have a harsher environment. Luckily, all the areas listed above with favorable legislation towards property tax abatement have climates in which a green roof can be economically beneficial.

-Comparative advantage

The key to continued profitability of the project lies on drawing an increased or more loyal customer base. The green roof will give a movie theater a comparative advantage over competitors for several reasons. Assuming the contract with the property owner passes on utility fees to the tenant, a green roof tenant will have lower monthly costs because of decreased heating and cooling use and decreased stormwater tax. The monthly cost of heating and cooling is relatively fixed regardless of how many tickets the theater sells. With low attendance periods on weekdays and in the afternoon, the movie theater won't have to staff as fully, but that also means they won't have high revenue. Therefore, the fixed cost of maintaining the theater's ambient temperature could be greater than the revenues obtained. Lowering those costs allows the theater a higher net in periods of low attendance. The theater will also lower fixed costs in periods of high attendance but the effect of lowering the fixed costs is greater relative to revenues in periods of low attendance.

The installation of a green roof provides a comparative advantage to the theater by influencing consumer choice. Rebranding the theater as sustainable can sway middle and upper income consumers that will choose a product through sustainable differentiation. According to a 2013 Green America report, 75% of small business owners who sell "green products or service saw in increase" in the sales of those products from 2008-2011 ("The Big Green Opportunity for Small Business in the U.S." 12). The ability to differentiate among competitors led green small businesses in the past

five years to achieve an advantage in their respective markets. Installing a green roof provides that differentiation in sustainability.

It will also attract new elderly and teenage customers involved in the ongoing operations of the green roof. Aside from the consumer draw, a green roof drives comparative advantage for a theater by affecting contractual negotiations with movie distributors. The typical alternative independent theater has difficulty securing first run screenings and lucrative contracts with distributors. The changed customer demand schedule initiated by the green roof can be an important bargaining chip in negotiations. Large multiplex theaters struggle significantly in getting customers to the theater during weekday and matinee showings. A typical theater will operate at 20% capacity for a whole week on average with the majority of viewers coming on Friday and Saturday nights. At those peak screenings, 70-90% of seats will be filled and there's little room for improvement. However, weekday screenings and, especially, weekday matinee screenings are very potentially profitable to a theater with only 0-5% of seats filled on average (Rimoch). Since green roofs provide a greater attraction during the daytime, they have the possibility to bump weekday matinee attendance up a few percentage points, which can move the total attendance for the week up 1-2 points.

If the alternative independent theater has data to suggest they outperform multiplexes, which would be expected with the addition of a green roof, movie distributors would consider these theaters more seriously in screening contract processes. It may even give the distributor enough incentive to consider working around the clearing clauses in contracts, getting the multiplex's approval to showcase a film at an alternative independent theater within the clearing area but only in weekday or matinee showings. This is an innovative solution that hasn't largely been implemented in the movie industry, as there's a bias toward the inertia of set contracts, which license the film to one theater and clear the surrounding area totally. If the distributor were to renegotiate these contracts, they would have a more efficient process for screening movies in licensing the films to match demand. It would be more beneficial for the alternative independent theaters by virtue of being able to secure popular movies. Therefore if the distributor used a financial incentive to convince the multiplex theater to put this gap in the clearing clause of the contract, all parties would be better off.

-Ongoing Operations and Maintenance

One of the benefits of a semi-intensive green roof is that the vast majority of the roof needs minimal maintenance. A roof-wide irrigation system installed at the time of implementation will lead to faster, fuller plant coverage, and less necessary maintenance throughout the course of the year. The extensive areas will need checkups two to three times per year, much like a lawn sprinkler system. These are necessary to ensure proper irrigation functioning (including blowing out the system in the winter) and repairing any minor roof membrane problems. This maintenance is best done by a green roof professional such as a staff member from the installation company.

The intensive parts of the green roof require more day-to-day maintenance including watering, weeding, and seeding or harvesting of plants. In the majority of community garden systems in the US, regular garden tasks are performed by a combination of community volunteers and garden staff members. For the movie theater green roof, a staff member could perform routine maintenance service for a short amount of time weekly. However, it's unrealistic for the maintenance to be performed solely by a staff member due to the high cost the theater would incur. For this reason, it's important to establish community demand for the garden before implementation to ensure there will be ample volunteer support to maintain the garden plots.

If the theater does find decreasing demand over time from community volunteers to maintain the garden, intensive plots could be shifted to feature a low-maintenance grass such as Sedum, turning the green roof from a semi-intensive roof to a fully extensive roof. While this does change the nature of the roof and the periphery services associated with growing produce or vegetables, it allows the theater to retain the environmental benefits of the roof without needing excessive staff to maintain it.

One of the benefits of a semi-intensive roof is that there are opportunities afforded to the movie theater in growing produce and vegetables on site. For example, the theater could host a community farmer's market on weekend mornings once or twice a month. This would bring additional customers onto the premises. Most theaters have enough space in their parking lot to host a medium sized farmer's market. If the neighborhood already has a market established, moving it to the theater won't come at a significant cost. Establishing a new farmer's market, which would involve contacting local small farmers as well as putting together a framework and marketing the events would take a significant amount of work. Barring a community volunteer running the organization for the market,

the theater would need to assign a staff member to the project for it to be a success. The farmer's market would not only attract customers but also enhance the community feel that the theater would strive for in rebranding.

Aside from running a farmer's market, a theater could harvest the produce grown on the green roof in the bar or restaurant. This would be a low-cost, organic way to supply the theater's produce needs and also provide a unique marketing point. Consumers have increasingly shown a demand for organic, local produce and the theater could brand its dishes as such. The comparative advantage derived from the theater is partially due to the uniqueness of a theater with a green roof. Using produce at the bar or restaurant which is grown on the roof augments the uniqueness and would encourage customers to purchase from the bar and restaurant. Since food and drink sales make up a large portion of theater profit, increasing those sales through a green roof will bring additional profitability to the theater.

-Financing

Ranging from $5 to $60 per square foot, a green roof is a relatively expensive project for a movie theater to implement. A movie theater owner might consider installing a green roof as he or she would consider installing a new heating and cooling system. Many independent theaters have found their facilities in need of a new HVAC system if occupy an older theater and the heating and cooling is key to maintaining occupant comfort in the theater ("Movie Theater Gains 'Great Escape' From Energy Costs"). However, compared to the installation of a new HVAC system, the green roof has widely proven environmental benefits, which can help the owners in securing government assisted funding.

As with any large investment, the movie theater can minimize payback time by paying in cash out of pocket, which won't require paying interest on any loans taken. If the theater is unable to pay upfront, there are financial assistance options on a federal and municipal level specific to energy efficient improvements. These government secured loans are specially suited to projects such as green roofs, having lower-interest rates or special structuring to incentivize green design projects. One such option is property secured loans such as the California PACE program, which ties the cost of improvement to the property value of the building. This allows owners or tenants to pay back

the loan using the reduced energy bills or taxes resulting from the completed improvement. A full listing of government programs for grants and other funding is available through the Environmental Protection Agency at www.epa.gov/home/grants-and-other-funding opportunities. In addition, the US small business administration has a directory and guide for environmental based funding at www.sba.gov/content/environmental-grants-loans.

Regardless of whether the project is internally or externally funded, the movie theater should pursue grant awards given out both federally and locally for innovative environmental design. Even as green roofs are becoming more common in American society, they're an impressive sustainable design feature. Any grant secured will reduce the funding burden of the project, shortening the payback time. ("Funding for Green Roofs") Outside of grants, many municipalities provide tax relief or funding assistance at the time of implementation of a green roof, which can, again, reduce the funding burden and shorten payback time.

-Return on Investment

The payback period for the green roof project hinges on capturing the environmental benefits of the green roof and turning them into increased profit. At the time of implementation, the roof adds a property value to the building up to $25 per square foot, which is calculated as a combination of estimates on the value of extensive and intensive roofs (Bianchini & Hewage, "Probabalistic Social-Cost Benefit Analysis of Green Roofs" 154). To better estimate the exact property value increase for a movie theater I used an income approach to commercial real estate appraisal. In this method, the property value increase is a multiple of the increased annual income stream from improvements. The exact multiplier is dependent on what's called the capitalization rate, which is a ratio of net income to the property value of a project. Using industry standard capitalization rates allows projection of property value increase given an increase in net income. In 2013, movie theaters average a capitalization rate of 6.4% (Gimmy et al. 122). The capitalization rate measures the rate at which income increases result in higher property value, with a lower capitalization rate indicating less improvement in property value for the same level of income increase. Therefore, with a capitalization rate of 6.4%, the property value increase for a green roof will be about 15.5 times the increase in annual income derived from the green roof. That income, and the subsequent property value increase will be detailed below. The property value increase is a one-time benefit added to the property and while it is based on the increase in annual net income from environmental and economic benefits, it is distinct from the two in this business plan because the owner, rather than the tenant, absorbs the

value. The tenant directly receives the annual profit increases from the green roof while the owner doesn't see this benefit directly. However, the owner does receive certain tangible benefits from the property value increase such as asset growth, increased collateral in loans, or increased capital when the "property is refinanced or sold" ("The High Performance Portfolio, Rethinking Simple Payback Period" 3). For this reason, it's counted in addition to the annual net income benefits in payback period calculations. However, it's not counted in net present value calculations because it doesn't result in definitive future cash flows. The property value calculations assume that the green roof is constructed in a state or municipality where the environmental upgrade results in property tax abatement. As the prevalence of property tax abatement policies increases, the number of locations optimal for a green roof will also increase.

In addition, in the implementation of a green roof on new construction, there's a one-time cost avoided of installing stormwater infrastructure on the building. Since the green roof will retain the majority of stormwater, the designer will not need to include as much stormwater mitigating infrastructure such as drains, pipes, and sewer openings. Many states and municipalities offer incentives to construct a green roof and those grant incentives are estimated at a benefit of $2.25 per sq. ft. for this type of green roof. In addition to those one-time benefits, the green roof will provide ongoing economic value in reduced stormwater or impervious space taxes and reduced energy use for heating and cooling. These calculations assume a moderate climate for implementation of a green roof. In more temperate coastal climates, the implementation of a green roof will result in less beneficial environmental outcomes and therefore less direct profitability.

One of the keys to the success of the green roof as an improvement project is increasing attendance and thereby increasing the profitability of the bar or restaurant, leading to a more profitable theater. However, these payback calculations don't take that into account, looking only at the return on investment from an environmental benefit standpoint, after which I'll discuss different possible scenarios for increased attendance and how that would improve the project's profitability.

For new construction, the green roof has a fairly wide range of possible payback times. Only including avoided costs from environmental benefits and therefore ignoring increased theater revenues from consumer choice and contract negotiations, the green roof averages a payback period of 3.52 years. In the best-case scenario, the reduced need for stormwater infrastructure, municipal grant, and property value increase covers the entire installation cost of the green roof. In that scenario, the green roof is a prof-

itable project in year one, generating over $150,000 in benefits above and beyond the installation cost. On the flip side; however, there is a possibility given these parameters that the green roof is an ongoing cost rather than a profitable endeavor. If the stormwater tax reduction and HVAC savings are not high enough to offset the ongoing operations and maintenance costs, the green roof will not pay for itself. However, again, this situation doesn't take into account any increased customer revenue and relies on the absolute worst-case assumptions of the environmental benefits.

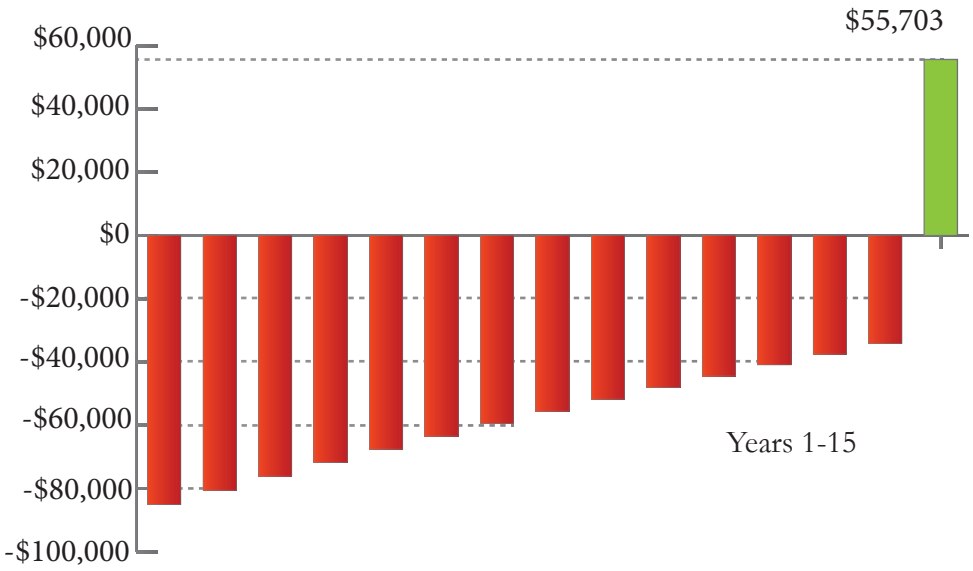
Table 6: Movie Theater New Construction Payback Period

Benefit	Time Scale	Benefit per sq. ft.	First Year	Subsequent Years
Grant/Tax Abatement	Once	$2.25	$22,500	-
Property Value Increase	Once	$73.28	$73,281	-
Reduced Stormwater Inf.	Once	$8.77	$87,700	-
Stormwater Fee Decrease	Annual	$0.39	$3,920	$3,920
HVAC Savings	Annual	$0.37	$3,750	$3,750
O & M costs	Annual	-$0.30	-$2,980	-$2,980
		Total	**$188,171**	**$4,690**

To calculate a 15-year net present value of the green roof for movie theater implementation, I used a discount rate of 4%. A 10-year treasury bill today would yield in the neighborhood of 2.75% while a 5-year bill

Table 7:

Movie Theater New Construction Net Present Value



would yield around 1.35%. The movie theater could invest the capital necessary for the green roof in other projects to stimulate revenues at the theater and if no such opportunities arose, in safe bet treasury bills. Over the 15 years, the bills would accumulate nearly a 4% return. Using the 4% figure assumes that the theater doesn't have better opportunities to grow the capital. However, I found it better to be conservative than overly optimistic about the value. Discounting future cash flows of reduced energy use, stormwater tax reduction, as well as the one-time need to reroof resulted in a 15-year net present value of $55,703, which amounts to $5.57 per square foot of the roof.

Table 8: Movie Theater Retrofit Construction Payback Period

Retrofit Construction		Benefit per sq. ft.	First Year	Subsequent Years
Benefit	**Time Scale**			
Grant/Tax Abatement	Once	$2.25	$22,500	-
Property Value Increase	Once	$24.91	$249,063	-
Stormwater Fee Decrease	Annual	$0.39	$3,920	$3,920
HVAC Savings	Annual	$1.50	$15,000	$15,000
O & M costs	Annual	-$0.30	-$2,980	-$2,980
		Total	**$287,503**	**$15,940**

The retrofit case of the green roof has a zero payback period, being profitable in the first year after construction. In most retrofit cases, some structural adjustments will need to be done to support the weight of the roof and the design process isn't as efficient as is the case with new design. This leads to a higher initial cost on the order of 20-40% (Castleton et al. 1589). However, the retrofit case does have a higher potential for annual environmental benefit as the increased energy reduction and stormwater avoidance provides direct economic benefits to the movie theater. The higher net income also results in a higher property value based on the income appraisal approach. The combined property value increase and municipal grant result in first year benefits over $272,000, significantly higher than the $250,000 initial cost. On top of that, the roof has annualized benefits over $15,000 from stormwater tax reduction and energy

savings. With first year net profits, the retrofit green roof can greatly increase the profitability of a movie theater in perpetuity.

In the retrofit case, the net present value amounts to $62,040, which can be understood as $6.20 per square foot of roofing. Without additional ticket or concession revenues from customer choice, the retrofit case only achieves a positive net present value in year 15 when the avoided cost of re-roofing is absorbed by the theater. This is despite the zero payback period because the net present value calculation doesn't take into account the property value increase as it provides no direct cash flows.

To estimate the effects that the green roof would have on an alternative independent theater's attendance and how that increased revenue would affect the payback period for the roof, I developed a model based on an average mid-size alternative independent theater. This theater would feature a bar and restaurant along with six screens, often showing a mixture of first-run blockbuster movies with documentaries or independently produced films. Two of the screens have a capacity of 200 seats ("big" theaters) while four of the screens have a capacity of 100 seats ("little" theaters). To optimize revenue, the theater would showcase the first-run screenings in the larger capacity theaters, saving older or less demanded movies for the smaller theaters. To begin the model, I built a screening pattern based on research of existing independent alternative theaters, which estimated a base attendance rate of 5% for weekday matinees, 15% for weekend matinees, 20% for weekday primetime screenings and 60% for weekend primetime showings. Customers rarely have identical demand for the movies in one theater, so I introduced a weighting function to demonstrate how demand peaks the weekend the movie debuts and reduces over the lifecycle of a movie.

After weighting the theaters based on seat capacity, the average attendance for the week is 20.41%, which is above average for movie exhibitors, considered by the industry to be "good" but not "great."

For a medium sized independent theater with a bar or restaurant attached, food and alcohol sales can make up between 40 and 60% of total revenue. In total, my model estimates that bar and restaurant revenue for this theater would be 45% of total revenues at just over $26,000 monthly. If the green roof increases movie attendance for the theater, it will have a subsequent increase in food and drink revenue. As more patrons visit the theater, the bar and restaurant will be more frequented. This is the case for movie theaters, such as the one in the model, which often see strong increases in food and drink revenue when they're able to attract first-run movie screenings. The green roof may even

have more potency in increasing bar and restaurant revenue relative to other attendance increases at the theater, as the green roof will instill an atmosphere at the theater, encouraging customers to turn a movie outing into a full night event with dinner or drinks. However, for the sake of being conservative in revenue projections, any additional food or drink revenue due to attendance increases from the green roof is proportional to the original distribution of bar and restaurant revenue.

Since the goal of this revenue projection was to estimate the decrease in payback period from the implementation of a green roof, I configured the model to calculate any changes in net ticket revenues above distributor split combined with increased food and drink profits. This figure can then be applied back into the payback period and net present value calculations for the green roof. The model afforded me the opportunity to manipulate many variables to different levels from the baseline projections to see how different changes in the customer base would affect the payback period. These variables included distributor/exhibitor split, bar and restaurant profit margins and changes in attendee makeup for different times and ticket prices. Ultimately, I manipulated the variables that the green roof was most likely to affect through comparative advantage.

A green roof provides a comparative advantage to a movie theater in presenting a sustainable, environmentally conscious choice to customers and movie distributors. The green roof will benefit the

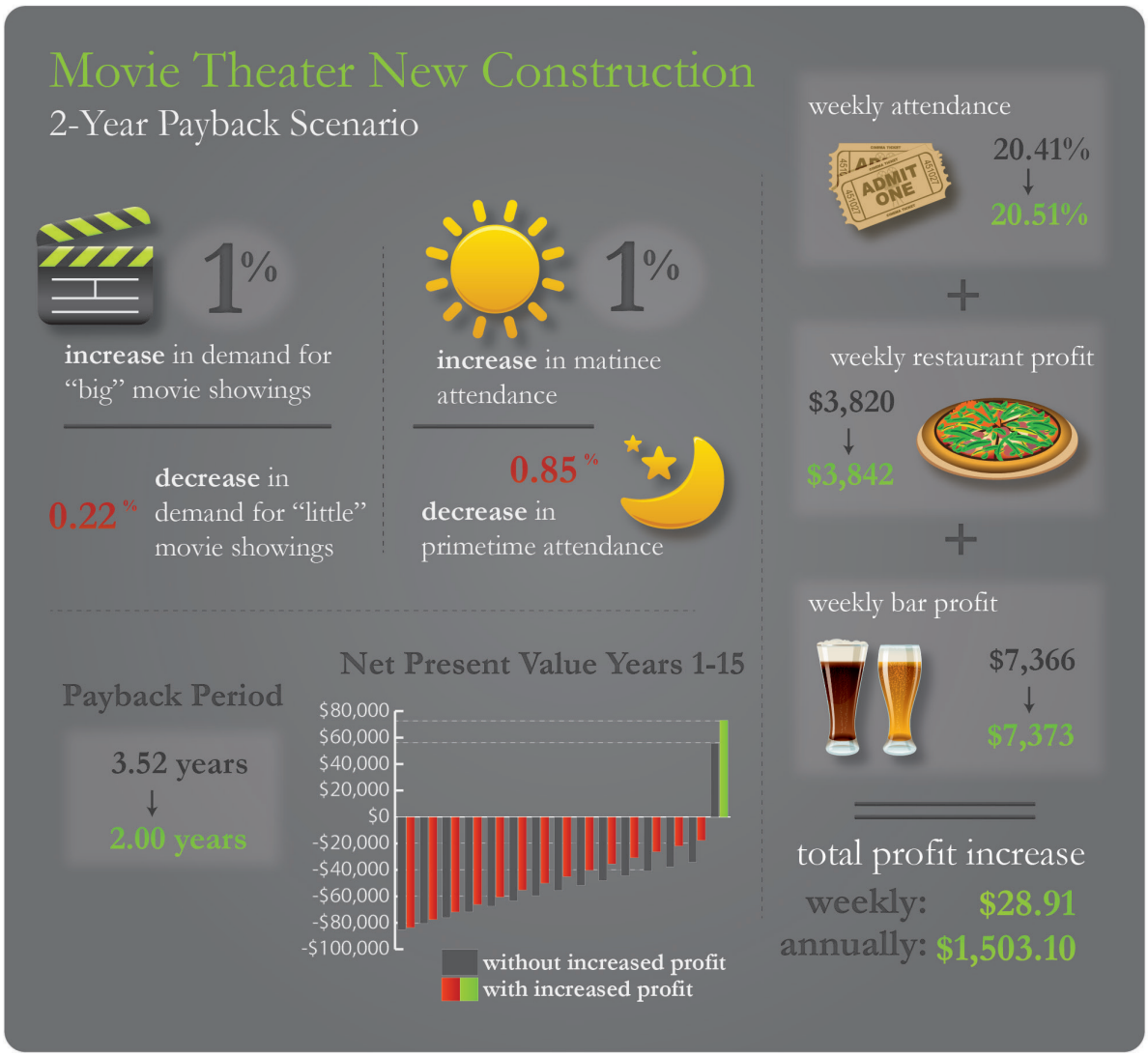
Table 9: Movie Theater Revenue Boost Projections

		Matinee Attendance Boost				
		0%	0.5%	1%	1.5%	2%
"Big" Demand Shift	0%	-	$7,716.13	$15,432.26	$23,148.39	$30,864.52
	1%	$5,888.86	$13,636.78	$21,384.71	$29,132.63	$36,880.55
	2%	$11,777.72	$19,557.43	$27,337.15	$35,116.87	$42,896.59
	3%	$17,666.57	$25,478.09	$33,289.60	$41,101.11	$48,912.63
	4%	$23,555.43	$31,398.74	$39,242.05	$47,085.36	$54,928.66

This table shows the additional net revenue a theater would receive from shifts in the matinee attendance and "big" demand variables

theater financially as the environmental benefit leads to an increased customer base and better bargaining terms with distributors in contractual negotiations. If the theater is viewed as comparatively better than competitors it will have increased attendance at all times; however, it is likely that the theater will have a proportionally greater increase in attendance during matinee screenings as the green roof would provide a daytime attraction. If the theater can better bargain with distributors, it will more likely be able to attract higher demand movies, which will increase customer attendance. Presumably, a high demand first-run movie would replace the least performing movie at the theater, moving the next best performing movie down a screen and so on, which is why the model shifts demand for

Table 10: Movie Theater 2-Year Payback Scenario



all of the "big" or "little" screens as opposed to an individual screen. Since the main two avenues in which comparative advantage will increase theater revenues are: increased attendance at different times of the day and more highly demanded movies, the variables I manipulated to develop revenue scenarios are matinee and primetime attendance shifts and "big" and "little" screen demand shifts.

The new construction green roof may be too costly for an alternative independent theater to install given an expected payback period of 3.52 years. To make it a more attractive investment, a theater would want an expected payback period of about two years. Therefore, I've crafted a scenario to give a theater a tangible impression of what reducing the payback period to two years would look like. With a 1% increase in demand for "big" screen showings (better movie screenings from better contractual bargaining chips) and a 1% matinee attendance increase (green roof affecting demand schedule) a theater could increase net profit by $29 weekly and $1,503.10 annually. With those demand increases the model allows for counter balancing changes in the primetime attendance and "little" screenings demand. This is a realistic possibility as some of the matinee increase might be a shift from primetime audiences. Additionally, licensing more highly demanded movies that increases "big" screen attendance could pull from the "little" screens demand. On a weekly basis, these variable shifts would increase total attendance from 20.41% to 20.51%. For most showings this is a small shift such as one more seat being filled. In this scenario, the increased attendance is accompanied by a small increase in food and drink revenues that comprises the majority of the profit increase for the theater. For instance, on Thursday nights in the model, restaurant revenue would increase by $13, about the price of an entrée. These snapshot figures demonstrate the low threshold of increased customer attendance necessary for a green roof to reach a low time horizon payback period on top of the existing environmental benefits.

-Advertising and Marketing

In theory, the green roof will be marketed over time by word of mouth through patrons and community volunteers. However, it will need an initial push to take hold as a means of rebranding the theater as sustainable. For an independent theater, the logo and physical imagery could be changed to reflect a greener building. In addition, pictures could be framed and hung in the hallways showcasing the community volunteers working on the rooftop. Positioned next to advertisements for upcoming movies, this would be a powerful way of connecting the environmental benefits of the building with

its main function, showcasing films. Through a moderate advertising campaign, a theater can more fully reap the consumer preference benefits of incorporating sustainability.

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Appendix

Shopping Center

Cost: The cost of implementing a green roof is typically between $5 and $60 per square foot. The cost of a semi-intensive roof, comprised of parts intensive and parts extensive, is close to $20 per square foot. In construction on a 20,000 square foot shopping center, I lowered the cost to $17.50 per square foot assuming economies of scale in design and installation that spread fixed costs over a larger total cost. For the retrofit case I included an additional $50,000 in expected costs for structural adjustment. That brings the total cost to $350,000 for the new construction and $400,000 for retrofit.

Payback period calculations

Environmental Benefits and costs avoided:

-Grant or tax abatement: outside of property tax abatement for environmentally beneficial construction, the green roof is expected to receive a grant or tax break in between $0 and $4.50 per square foot. As with other benefit calculations, I used an average of low and high-end expectations, resulting in an expectation of $2.25 per square foot. For a 20,000 square foot green roof, that amounts to $45,000.

-Reduced stormwater infrastructure: when the green roof is installed with new construction, the building has a one time avoided cost of installing stormwater-mitigating infrastructure. Typically, a designer can avoid 30-60% of necessary stormwater infrastructure which results in avoided costs of $2.80-$9.30 per square foot for extensive roofs and $9.30-$30 for intensive roofs. Given that the shopping center will not be completely covered by the green roof, I reduced the benefits of stormwater infrastructure by 25%, expecting that there will be additional roof runoff not captured by the green roof. For a semi-intensive mix of 80% extensive roofing and 20% intensive roofing this amounts to a low estimate of $3.64 per square foot and a high estimate of $11.94 per square

foot. Taking the average of $7.88 per square foot for a 20,000 square foot shopping center results in avoided costs of $155,750, but only for new construction.

-Stormwater tax reduction: academic literature states the benefit of a green roof in avoiding stormwater tax between $0-$0.034 annually per square foot. However, this is lower than my observed stormwater tax reduction potential and other current sources on stormwater taxes. Therefore, I used $0.39 per square foot in calculating the benefits, which results in $7,840 annually for a 20,000 square foot shopping center. That translates to a monthly reduction of $653.33, which is on the low end of my observed potential for stormwater tax reduction. However, given that there are different opinions in the literature about the dollar value of stormwater tax reduction I found it better to be conservative and keep this figure rather than increase it.

-Heating and cooling savings: for new construction a building can reduce its energy use by $0.15-$0.60 per square foot. As in the case with the stormwater infrastructure reduction, I discounted this benefit since the green roof will not completely cover the shopping center. Therefore, I used an average of $0.28 per square foot, which results in annual benefits of $5,625. For the retrofit construction, the green roof has an expected benefit of $1.50 per square foot, which results in $30,000 in annual benefits.

-Operations and maintenance costs: annual O&M costs are estimated at $0.06 per square foot for an extensive roof and $1.25 per square foot for an intensive roof. For an 80%-20% mix semi-intensive roof this equates to $0.298. For the shopping center, I reduced the average cost by 20% to reflect increasing economies of scale in maintenance as the green roof area grows. This amounts to a cost of $0.248 per square foot and an annual cost of $4,960 for a 20,000 square foot green roof.

-Property value increase: the property value increase is calculated using the income approach to real estate appraisal, where the appraisal value is a reflection of annual net income flows. Shopping centers in 2013 average a capitalization rate of 8%. This means that any increases in annual net income result in a property value increase by a factor of 12.5. For the new construction shopping center green roof, annual income flows increase by $8,505, resulting in a property value increase of $106,312.50. For retrofit construction, the annual net income increases by $32,880, resulting in a property value increase of $411,000. Both of these property income increases would normally be accompanied by increased property taxes that could potentially offset any benefit from the property value increase.

However, the business case assumes property tax abatement for an environmental improvement. For this reason, the property value increase is still calculated as a benefit. Also, increases in consumer revenue flows are not calculated in property value increase because they would result in increased property taxes, which would not be abated through government programs and therefore offset the benefit of the property value increase.

Calculations: The payback period is calculated as the number of years it would take for the shopping center to recoup the investment cost of the green roof. For new construction, the first year benefits are $315,567.50 while subsequent years have net benefits of $8,505. This results in a payback period of the $350,000 investment in 5.049 years. For the retrofit construction, the roof is paid back immediately as the property value increase of $411,000 completely offsets the $400,000 cost.

Net Present Value

The net present value calculates the discounted present value of future cash flows and is therefore a different calculation than payback period with some similar inputs and some different inputs.

Future Cash Flows:

-Grant or tax abatement: see above.

-Reduced stormwater infrastructure: see above.

-Stormwater tax reduction: see above.

-Heating and cooling savings: see above.

-Operations and maintenance costs: see above.

-Reduced need to re-roof: typically, a commercial roof would need to be replaced once every 15 years. With the addition of a green roof, the roof longevity extends to 30-40 years. Therefore, the green roof benefits a building in a one time future avoided cost of needing to reroof. A typical re-roofing costs $15 per square foot. For a 20,000 square foot green roof, this results in a future avoided cost

of $300,000. The avoided cost would come in year 15 of the calculations and is discounted back to the present.

-Property value increase: though property value increase is a benefit to property owners in ability to use as collateral, refinance, or resell, it doesn't result in tangible increased cash flows and is therefore not included in the net present value calculations.

Calculations: The net present value for both the new and retrofit construction cases is calculated as the discounted 15-year future cash flows. In the first year, the benefits of grant or tax abatement and reduced stormwater infrastructure are realized and therefore not discounted. In subsequent years, the stormwater tax reduction and heating and cooling savings less the ongoing maintenance costs are discounted at a rate of 4% back to the present year. Then, in year 15, the avoided re-roofing cost is discounted back to the present as well. This results in a 15-year net present value of $88,644 for new construction and $116,954 for retrofit construction. In both cases, the net present value is turned positive by the avoided cost of re-roofing.

Two Year Payback Period Calculation

To calculate the two year payback requirements for the shopping center green roof, I used the solver function in excel, altering the payback period calculation by adding a term for increases in consumer driven revenue. Excel solved the equation by imputing $1,788 for the annual net income increase, which resulted in a higher property value increase of $128,664 and the payback period of two years.

Movie Theater

Cost: The cost of implementing a green roof is typically between $5 and $60 per square foot. The cost of a semi-intensive roof, comprised of parts intensive and parts extensive, is close to $20 per square foot. In construction on a 10,000 square foot movie theater this amounts to $200,000. For

the retrofit case I included an additional $50,000 in expected costs for structural adjustment. That brings the total cost to $250,000 for retrofit.

Payback period calculations

Environmental Benefits and costs avoided:

-Grant or tax abatement: outside of property tax abatement for environmentally beneficial construction, the green roof is expected to receive a grant or tax break in between $0 and $4.50 per square foot. As with other benefit calculations, I used an average of low and high-end expectations, resulting in an expectation of $2.25 per square foot. For a 10,000 square foot green roof, that amounts to $22,500.

-Reduced stormwater infrastructure: when the green roof is installed with new construction, the building has a one time avoided cost of installing stormwater-mitigating infrastructure. Typically, a designer can avoid 30-60% of necessary stormwater infrastructure which results in avoided costs of $2.80-$9.30 per square foot for extensive roofs and $9.30-$30 per square foot. For a semi-intensive mix of 80% extensive roofing and 20% intensive roofing this amounts to a low estimate of $4.10 per square foot and a high estimate of $13.44 per square foot. Taking the average of $8.88 per square foot for a 10,000 square foot shopping center results in avoided costs of $87,700, but only for new construction.

-Stormwater tax reduction: academic literature states the benefit of a green roof in avoiding stormwater tax between $0-$0.034 annually per square foot. However, this is lower than my observed stormwater tax reduction potential and other current sources on stormwater taxes. Therefore, I used $0.392 per square foot in calculating the benefits, which results in $3,920 annually for a 10,000 square foot movie theater. That translates to a monthly reduction of $326.68, which is on the low end of my observed potential for stormwater tax reduction. However, given that there are different opinions in the literature about the dollar value of stormwater tax reduction I found it better to be conservative and use this figure rather than increase it.

-Heating and cooling savings: for new construction a building can reduce its energy use by $0.15-$0.60 per square foot. Therefore, I used an average of $0.28 per square foot, which results in annual benefits of $5,625. For the retrofit construction, the green roof has an expected benefit between

$0.60 and $2.40 per square foot. Therefore I used $1.50 per square foot, which results in $30,000 in annual benefits.

-Operations and maintenance costs: annual O&M costs are estimated at $0.06 per square foot for an extensive roof and $1.25 per square foot for an intensive roof. For an 80%-20% mix semi-intensive roof this equates to $0.298. This amounts to an annual cost of $2,980 for a 10,000 square foot green roof.

-Property value increase: the property value increase is calculated using the income approach to real estate appraisal, where the appraisal value is a reflection of annual net income flows. Movie theaters in 2013 average a capitalization rate of 6.4%, meaning that any increases in annual net incomes result in a property value increase by a factor of 15.5. For the new construction movie theater green roof, annual income flows increase by $4,690, resulting in a property value increase of $73,281.25. For retrofit construction, the annual net income increases by $15,940, resulting in a property value increase of $249,063. Both of these property income increases would normally be accompanied by increased property taxes that could potentially offset any benefit from the property value increase. However, the business case assumes property tax abatement for an environmental improvement. For this reason, the property value increase is still calculated as a benefit. Also, increases in consumer revenue flows are not calculated in property value increase because they would result in increased property taxes, which would not be abated through government programs and therefore offset the benefit of the property value increase.

Calculations: The payback period is calculated as the number of years it would take for the shopping center to recoup the investment cost of the green roof. For new construction, the first year benefits are $188,171.25 while subsequent years have net benefits of $4,690. This results in a payback period of the $200,000 investment in 3.52 years. For the retrofit construction, the roof is paid back in the first year as the property value increase of $249,063 almost completely offsets the $250,000 cost.

Net Present Value

The net present value calculates the discounted present value of future cash flows and is therefore a different calculation than payback period with some similar inputs and some different inputs.

Future Cash Flows:

-Grant or tax abatement: see above.

-Reduced stormwater infrastructure: see above.

-Stormwater tax reduction: see above.

-Heating and cooling savings: see above.

-Operations and maintenance costs: see above.

-Reduced need to re-roof: typically, a commercial roof would need to be replaced once every 15 years. With the addition of a green roof, the roof longevity extends to 30-40 years. Therefore, the green roof benefits a building in a one time future avoided cost of needing to reroof. A typical re-roofing costs $15 per square foot. For a 10,000 square foot green roof, this results in a future avoided cost of $150,000. The avoided cost would come in year 15 of the calculations and is discounted back to the present.

-Property value increase: though property value increase is a benefit to property owners in ability to use as collateral, refinance, or resell, it doesn't result in tangible increased cash flows and is therefore not included in the net present value calculations.

Calculations: The net present value for both the new and retrofit construction cases is calculated as the discounted 15-year future cash flows. In the first year, the benefits of grant or tax abatement and reduced stormwater infrastructure are realized and therefore not discounted. In subsequent years, the stormwater tax reduction and heating and cooling savings less the ongoing maintenance costs are discounted at a rate of 4% back to the present year. Then, in year 15, the avoided re-roofing

cost is discounted back to the present as well. This results in a 15-year net present value of $55,703 for new construction and $62,040 for retrofit construction. In both cases, the net present value is turned positive by the avoided cost of re-roofing.

Revenue Projection Model

Background: The revenue projection model is based on an average mid-size alternative independent theater. This theater would feature a bar and restaurant along with six screens, often showing a mixture of first-run blockbuster movies with documentaries or independently produced films. Two of the screens have a capacity of 200 seats ("big" theaters) while four of the screens have a capacity of 100 seats

Table 11: Movie Theater Showing Schedule

	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday
"Little" 1	(12:00)	(12:00)	(12:00)	(12:00)	(12:00)	(12:00)	(12:00)
	(3:00)	(3:00)	(3:00)	(3:00)	(3:00)	(3:00)	(3:00)
	9:00p	9:00p	9:00p	9:00p	9:00p	9:00p	9:00p
"Big" 1	(12:30)	(12:30)	(12:30)	(12:30)	(12:30)	(12:30)	(12:30)
	(2:40)	(2:40)	(2:40)	(2:40)	(2:40)	(2:40)	(2:40)
	(4:50)	(4:50)	(4:50)	(4:50)	(4:50)	(4:50)	(4:50)
	7:00p	7:00p	7:00p	7:00p	7:00p	7:00p	7:00p
	9:20p	9:20p	9:20p	9:20p	9:20p	9:20p	9:20p
"Little" 2	(12:40)	(12:40)	(12:40)	(12:40)	(12:40)	(12:40)	(12:40)
	5:30p	5:30p	5:30p	5:30p	5:30p	5:30p	5:30p
"Little" 3	(3:10)	(3:10)	(3:10)	(3:10)	(3:10)	(3:10)	(3:10)
	5:10p	5:10p	5:10p	5:10p	5:10p	5:10p	5:10p
	7:45p	7:45p	7:45p	7:45p	7:45p	7:45p	7:45p
	9:40p	9:40p	9:40p	9:40p	9:40p	9:40p	9:40p
"Little" 4	(12:20)	(12:20)	(12:20)	(12:20)	(12:20)	(12:20)	(12:20)
	(2:00)	(2:00)	(2:00)	(2:00)	(2:00)	(2:00)	(2:00)
	4:20p	4:20p	4:20p	4:20p	4:20p	4:20p	4:20p
	7:15p	7:15p	7:15p	7:15p	7:15p	7:15p	7:15p
	9:30p	9:30p	9:30p	9:30p	9:30p	9:30p	9:30p
"Big" 2	(11:55)	(11:55)	(11:55)	(11:55)	(11:55)	(11:55)	
	2:20p	2:20p	2:20p	2:20p	2:20p	2:20p	2:20p
	5:00p	5:00p	5:00p	5:00p	5:00p	5:00p	5:00p
	6:45p	6:45p	6:45p	6:45p	6:45p	6:45p	
	7:30p	7:30p	7:30p	7:30p	7:30p	7:30p	7:30p
	9:50p	9:50p	9:50p	9:50p	9:50p	9:50p	9:50p

("little" theaters). To optimize revenue, the theater would showcase the first-run screenings in the larger capacity theaters, saving older or less demanded movies for the smaller theaters. To begin the model, I built a screening pattern based on research of existing independent alternative theaters, which estimated a base attendance rate of 5% for weekday matinees, 15% for weekend matinees, 20% for weekday primetime screenings and 60% for weekend primetime showings. Customers rarely have identical demand for the movies in one theater, so I introduced a weighting function to demonstrate how demand peaks the weekend the movie debuts and reduces over the lifecycle of a movie.

The model looks at a snapshot week of the movie theater. From a Friday to the following Thursday, there are 173 showings, 69 of which are matinee screenings.

I then instituted a degree of variance off the baseline attendance figures and weighted the attendance, predicting higher demand for bigger and more recent movies.

I estimated the breakdown of attendance per showing, assuming matinee showings would have a higher percentage of elderly attendees and weekend primetime showings would have more full price tickets than discounted tickets. I then calculated ticket revenue from these showings using prices of $6.00 for students or elderly viewers, $7.00 for matinees, and $9.00 full price tickets. To estimate net revenue from ticket sales I used a 90-10 split for the "big" movies, which is the most frequent type of negotiation agreement for highly demanded movies. In that case the theater would keep 10% of the revenue after taking the "house nut," a fee used to cover operating costs. I did not estimate the house nut as my focus was on change in profit from affecting demand variables and not the initial profit. The "house nut" would be the same regardless of changes in demand and would therefore be constant between the initial model and adjusted model. Therefore it could be ignored. For the "little" movies, I used a sliding scale estimate where the theater retains a higher percentage of revenue as the movie has been in theaters longer. For the most recent "little" movie, I estimated the theater would keep 30% going to 35% for the next most recent, 40% for the third most recent and 45% for the oldest "little" movie still in the theater. This gave me a projection of the net revenue from ticket sales.

I then estimated bar and restaurant revenue from each patron attending the theater. To do this, I estimated how many dollars would be spent at the restaurant and bar for every dollar spent on a ticket for a showing. I included variance in this measure as well to reflect that more would be spent proportionally in attending primetime and weekend showings than during weekday and matinee

Table 12: Movie Theater Showing Weighted Attendance

	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday
Little 1	8.55%	19.34%	22.42%	5.61%	6.29%	10.20%	7.74%
	9.31%	23.67%	21.60%	7.32%	8.14%	9.32%	10.42%
	92.58%	92.17%	32.37%	27.73%	27.14%	26.27%	26.80%
Big 1	5.75%	21.19%	16.05%	4.33%	7.62%	8.61%	8.92%
	4.58%	21.83%	21.53%	9.32%	7.02%	5.92%	3.97%
	5.63%	19.35%	17.35%	8.26%	6.00%	7.12%	3.48%
	75.03%	73.19%	25.12%	23.16%	22.48%	26.50%	27.78%
	76.01%	74.63%	27.42%	27.04%	27.72%	25.84%	26.98%
Little 2	4.67%	18.71%	18.87%	6.21%	3.84%	7.56%	8.95%
	76.70%	76.40%	24.15%	25.51%	25.79%	24.39%	24.51%
Little 3	4.29%	10.62%	11.90%	2.51%	5.39%	3.94%	2.45%
	43.40%	45.06%	14.36%	16.83%	13.99%	16.37%	14.09%
	44.08%	43.58%	14.05%	14.02%	15.62%	16.23%	14.89%
	44.64%	45.95%	13.58%	16.24%	13.59%	13.23%	13.94%
Little 4	3.52%	8.70%	7.89%	1.40%	2.07%	1.80%	1.34%
	3.60%	6.56%	6.34%	3.60%	3.17%	3.37%	3.59%
	30.74%	31.17%	11.04%	9.62%	10.69%	9.27%	9.13%
	30.10%	29.28%	9.78%	10.02%	9.97%	11.25%	11.03%
	30.60%	29.07%	10.69%	9.84%	9.77%	10.88%	8.75%
Big 2	3.20%	12.42%	9.48%	4.69%	2.59%	2.52%	
	44.53%	43.92%	13.92%	13.86%	15.72%	13.41%	13.81%
	46.87%	44.93%	15.39%	14.09%	15.34%	16.40%	13.83%
	44.96%	46.14%	13.47%	14.34%	16.83%	15.08%	
	46.83%	43.49%	14.79%	14.91%	13.22%	16.06%	15.20%
	45.17%	46.49%	13.68%	14.98%	14.22%	15.62%	16.51%
Average	34.41%	39.13%	17.44%	12.90%	12.78%	13.37%	13.49%

showings. On the low-end, I estimated $0.22 of food and drink revenue for every dollar spent on tickets during weekday matinees and on the high-end $1.60 per dollar spent on tickets during Saturday primetime showings. I then cross-referenced these estimates with the ticket revenue from the

show times to aggregate expected bar and restaurant revenue. For example, a Saturday night showing might bring in $1,012.50 in ticket sales and $1635.11 in bar and restaurant revenue from the patrons attending that showing.

To calculate restaurant profit I used the industry standard rule of thirds where food costs are tripled to cover labor and utilities and then an additional 25% is tacked on to the price to generate profit for the restaurant. Therefore, restaurant profit in my model is calculated as 25% of restaurant revenue.

For bar profit, I first estimated the number of bartenders or bar backs (bartenders' assistants) necessary to staff the bar on that night, and estimated their salary at $15 per hour. After taking their salary out of the bar revenue, I estimated that 20% would cover costs of alcohol and the remaining 80% would be profit.

Aggregating the net revenues from ticket sales and food and drink sales gave an approximation of a theater's profit from week to week. At that point, I could manipulate the underlying demand variables I had included: base attendance rates, attendance demographic splits, ticket prices, demand base on movie, bar and restaurant proportional revenue, bar and restaurant profit take, and daily and hourly demand shifts. I could then compare adjusted net revenue figures with initial revenue figures to estimate how a small shift in one of the underlying variables could affect the theaters profitability and therefore how a green roof might increase profitability from consumer choice.

To check the accuracy of the model I had several feedback sensors that I could compare to academic and observed industry figures. For example, I consistently checked the overall attendance figure and bar and restaurant percentages of total revenue to ensure they were not out of line.